EVALUATION OF RESISTANCE TO *Selenothrips rubrocinctus* Giard AMONG VARIOUS *Psidium* GENOTYPES BASED ON SOME FRUIT PARAMETERS

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INTRODUCTION

The common guava (*Psidium guajava* L.), a native to tropical America (Malo and Campbell, 1968; Pope, unpublished manuscript, Ruehle, 1959), was first introduced into Hawaii prior to 1800 by Don Marin (Boyle *et al*., 1957, Neal 1965). This plant was later reported to be attacked by the red-banded thrips (RBT), *Selenothrips rubrocinctus* Giard., in the West Indies in 1909 (Franklin, 1909). This thrips, an economically important introduced pest, was first recorded on Oahu in 1910 (Bagnall, 1910). In Hawaii, it was first collected on wild guavas in 1937 on the island of Kauai (Sakimura, 1938). Subsequently, commercial and wild guavas were reported to be heavily damaged between 1967 and 1969 on Oahu, and in 1973 it was recognized as a major pest which caused scarification on the fruits and leaves of guava (Mitchell, 1973). RBT are one of the most common thrips on foliage in Hawaii (Anonymous, 1979).

Silvery discoloration of the leaf tissue often comprised the first visual symptoms of feeding injury caused by this thrips. The discoloration resulted from the entry of air in the damaged cells caused by this thrips (Ananthakrishnan, 1971). The minute silvery spots subsequently turn brown and the coalescence of many of these spots on the leaf or fruit surfaces causes them to be russeted under severe attacks (Russell, 1912). Yokoyama (1979) has found that thrips scars caused by *Frankliniella occidentalis* detract from the appearance of table grape clusters and can result in an unmarketable product when injury is extensive.

Research on guava improvement was initiated in Hawaii in 1951 by Dr. H. Beaumont, who envisioned along with others the great commercial potential of this fruit (Bowers and Nakasone, 1960; Popenoe, 1969). Readily available and inexpensive plant material, reliable methods of propagation (Hamilton and Nakasone, 1967), wide adaptability (Dasarathy, 1951), hardiness and tolerance to a wide variety of soil types (Bakhashi and Randhawa, 1967; Hayes, 1966), and usefulness as juice, puree, jam and jelly products (Ahmad, 1961; Boyle et al., 1957; Brekke, 1971; Ruehle, 1948; Warner, 1886) are supportive factors of the potential that guava has as a commercial crop in Hawaii.

At present the 'Beaumont' (Bowers and Nakasone, 1960) and 'Ka Hua Kula' (Nakasone and Ito, 1978), are the predominant cultivars grown commercially in Hawaii. Production of cultivated guava has increased almost five times over the past six years with production at slightly over 100,000 kg in 1977 (Anonymous, 1978). This represents a farm value of $186,000 or about a 450% increase since 1972 (Anonymous, 1976). In 1977 there were about 270 hectares or eight times the area of 1972 with the major plantings located in Hilo, Kahuku and Kilauea on the islands of Hawaii, Oahu and Kauai, respectively. This represents 13% of the total number of acres devoted to fresh fruit production in the State and ranks second to papaya with about 878 hectares in production. By 1977 there were a total of 96 guava farms, four times as many as there were in 1972.

Despite these notable increases, the value of sales per acre ($280 per acre in 1977) was small compared to that for papaya, avocado or banana ($3500, $1675 and $1650, respectively).

Insecticide costs, pollution and impact on nontarget organisms, rigid regulations on pesticide use, restricted export of guava puree processed from treated fruits, together with insect resistance to insecticides and the lack of new safe compounds with different modes of action are factors that emphasize the need for developing host plant resistance (Maxwell, 1972) as an attractive and effective alternate to insecticide use.

This study continued investigations of resistance in guava to the RBT, which could be utilized in breeding for insect resistance or provide parameters which may be used in cultural practices. The objectives of this research project are:

1. Directly compare the effects of RBT injury on fruits from clone 157 with normally mature fruits of this clone.
2. Evaluate differences in fruit preference of the RBT among various local acid-type selections during the fruiting season and provide preliminary information on the performance of eight other *Psidium* genotypes.
3. Provide a basis of evaluation by relating the following fruit parameters with preference: length (L), width (W), moisture content (M), fruit firmness (PRES), soluble solids (SS), % nitrogen (N), % potassium (K), % phosphorus (P),

% calcium (CA), and % magnesium (MG).

4. Determine whether levels of K fertilization influence thrips response and whether there is a significant K interaction with *Psidium* genotype.
5. Monitor N and K concentrations in the leaf tissue of guava over time, so as to provide another means of detecting responses in the plant to the application of K fertilizer.

LITERATURE REVIEW

GUAVA

History and distribution

The first account of guava was written in 1526 by Gonzalo Fernandez de Oviedo y Valdez (Ruehle, 1948). It was distributed from Mexico (Pope, unpublished manuscript), southward to Guatemala (Lundell, 1940), Venezuela (Pittier, 1926), Surinam (Pulle, 1906), Peru (Pope, unpublished manuscript) and Brazil (Von Mueller, 1888). Guava was commonly found within the Caribbean from Cuba (Ruehle, 1948), southward into Jamaica (Grisebach, 1864), Haiti (Barker and Durdeau, 1930), Puerto Rico (Soto, 1960), Barbados (Gooding *et al.*, 1965), and Trinidad and Tobago (Williams and Williams, 1951).

Rev. Sereno Bishop stated guavas were a choice garden fruit in Hawaii by the late 1830's (Pope, unpublished manuscript). It escaped cultivation about 20 years later growing throughout Hawaii in wet valleys and on slopes of mountains (Boyle *et al.*, 1957; Pope, unpublished manuscript). Guava was recorded south of Hawaii in Samoa by Reinecke in 1893. It is known in Samoa as *kua'ua* and currently occurs widespread (Parham, 1972). This plant has become widespread throughout Malaya, where it is known as *jambu batu* (Allen, 1967). The Spanish are believed to have carried the tree to the Philippines (Ruehle, 1948). It is very common and widely distributed in the open areas of the Philippine Islands (Brown, 1946).

The introduction of a common yellow guava to the Hawaiian Islands from Australia in 1851 by Mr. C. Montgomery was believed to be just another introduction of this plant (Pope, unpublished manuscript).

Guava was observed early in the 17th century in India (Hayes, 1966; Gandhi, 1957) where it is well adapted and is cultivated throughout the country (Chopra *et al.*, 1956).

The arrival of guavas in South Africa occurred around 1870 (LeRiche, 1951). Western Africa has planted guavas as a fruit crop in South Leone, Gold Coast and North and South Nigeria (Dalziel, 1937).

Nevertheless, guava has become a pest in several tropical and subtropical areas (Hayes, 1966). It has been reported as a pasture weed in Hawaii, Florida and Cuba (MacCaughey, 1917; Ruehle, 1948). The scattering of seeds by birds has aided in the distribution of this species in many areas (Ruehle, 1948).

Taxonomy

Guava belongs to the family Myrtaceae which dominates the Australian vegetation and ranks first in economic importance (Smith-White, 1948). Leaves of this family characteristically have oil glands (Smith-White, 1948). Triterpenoid and essential oils were recorded in the leaves of guava collected in North Borneo (Arthur, 1954). Varieties may be differentiated by the amino acid content of the leaves (Winchester, 1975).

Myrtaceae, in the order *Myrtiflora*, is divided into three tribes, the Chamaelaucoideae, Leptospermoideae, and Myrtoideae. *P. guajava* belongs to Myrtoideae, which is chiefly centered in central and south America. A secondary center of diversity is located in tropical southeastern Asia (Smith-White, 1948).

The genus *Psidium* contains 120-150 species spreading over tropical and subtropical America and the West Indies (Leon and Alain, 1953). *Psidium* is a Greek derivation referring to the structural similarities to the pomegranate fruit (Pope, unpublished manuscript).

Puerto Rico groups guava by fruit type. The Dominican, Peruvian and wild Puerto Rican groups are the three major types with the latter group comprising the bulk of the guava fruit trade (Aponte, 1963). Hawaiians distinguished a few varieties based on fruit types. *Kwava-lemi* and *kuava-'oke'o* referred to the sour lemon guava with pink and white pulp, respectively. *Kuava-monona* referred to a type with sweet pink pulp, larger seeds and thicker skin (Neal, 1965). However, many of the guava species are known solely by vegetative characters (Leon and Alain, 1953). The name *guajava* originated from the West Indian name *guajebe* (Pope, unpublished manuscript).

P. pomiferum and *P. pyriferum* have been considered varieties or synonyms of *P. guajava* (Bois, 1928; Britton, 1918; Fawcett and Rendle, 1926; Grisebach, 1864). The berries were shaped globose and obovate, respectively (Grisebach, 1864).

Botany

Guava may be an evergreen tree or shrub 2 to 8 meters high. The green flushes or twigs on the widely-spreading branches are square and velvety. A distinctive mottled pattern of green and brown on the trunk may result from the occasional scaling off of the smooth reddish-brown bark. Leaves, 6-14 cm x 3-6 cm, are prominently feather-veined, oblong or oval, blunt at the base, tomentose below, smooth above, opposite and spaced 1.5-4.0 cm between internodes with a petiole 3-7 mm long. Cracking of the bell-shaped calyx occurs nearly twenty-four hours prior to anthesis. A perfect or bisexual flower 2.5 cm or more across is revealed with four to six white petals subtending numerous white stamens varying in number from 160 to 400 with yellow anthers. Pollen grain size, shape and viability vary by variety. Stigmatic surfaces are receptive from two or three hours following anthesis until about 48 hours. Fruit is a berry turning yellow upon ripening. Shape ranges from pyriform to globose-obovoid with yellow, white or pink pulp (Backer and Bakhuizen van den Brink, 1963; Balasubrahmanyam, 1959; Hamilton and Seagrave-Smith, 1954; Malo and Campbell, 1968; Neal, 1965).

The haploid chromosome set of n = 11 for guava may have been secondarily derived from an original primitive set of six. Thus secondary polyploids may have been operative at some early stage in the development of the Myrtaceae family (Smith-White, 1948).

Flowering is axillary on the current season's growth (Dasarathy, 1951) with greatest set from flowers open to the numerous bees that visit them (Hayes, 1966). The guava takes nearly five months for fruit maturation following floral anthesis (Gandhi, 1957). Variations in shape, acidity and color among wild guavas make sexual propagation by seed unsatisfactory (Ahmad, 1961; Malo and Campbell, 1968; Pope, unpublished manuscript). Seedlings derived from controlled pollinations may fruit in two to three years following transplanting (Hamilton and Seagrave-Smith, 1954; Ruehle, 1948). Guavas are commonly cross-pollinated (Balasubrahmanyam, 1959).

Uses and products

Guava products, other than puree, juice, jam or jelly are canned fruit rinds, guava butter, gumdrop preserves, guava powder, shortcake, salad, ice cream, sherbet, syrup and pudding (Ahmad, 1961; Gandhi, 1957; Little and Wadsworth, 1964; Orr, 1959; Ruehle, 1948). These fruit have a favorable low waste index value of 4% in comparison to avocado (46-58%), banana (34-40%), mango (47%), papaya (25%), passion fruit (67%) and pineapple (41%) and contain about 80 ug of vitamin A per 100 g of fruit (Czyhrinciw, 1969).

Guava leaves have been used medicinally as an astringent to counteract diarrhea and dysentery (Chopra *et al.*, 1956; Leon and Alain, 1953). Hawaiians made a medicinal tea from guava leaf buds (Neal, 1965). Guava was one of four plants out of 101 plant species in Hawaii that possessed very effective antibacterial properties (Bushnell *et al.*, 1950). The leaves and flowers very effectively inhibited the bacterial strain *Micrococcus pyrogenes* var. *aureus* and was moderately effective against both *M. pyrogenes* and *E. coli*. Guava fruit extracts were moderately effective upon five enteric pathogens, *Salmonella typhosa*, *Sal. montevideo*, *Sal. schottmuelleri*, and two serological types of *Shigella pardysenteria* (Bushnell *et al.*, 1950).

The strong and elastic wood of guavas have been used for cattle yokes, agricultural implements, woodworking and handles (Allen, 1967; Fawcett and Rendle, 1926; Leon and Alain, 1953; Little and Wadsworth, 1964). Wood cut from guavas growing wild in the hills of Tahiti and Eimee was sold as early as 1939 for firewood aboard ships (Pope, unpublished manuscript). Guava bark contains appreciable amounts of tannins for tanning (Leon and Alain, 1953) and a black cloth dye was obtained by boiling leaves and bark with certain other plants (MacCaughey, 1917).

Production

Commercially grown guavas in Hawaii are entirely processed, primarily into puree with a fraction into juice for jelly stock. In 1971 there were an estimated 2.7 million kg of fruit available to processors in Hawaii (Brekke, 1971). Uniformity and constancy are requirements for developing high quality processed fruit products (Bowers and Nakasone, 1960).

The U. S. Mainland market required as estimated 280,000 kg of processed guavas in 1972. Single strength hot pack guava nectar in cans was the primary outlet during 1972 for guava nectar in Hawaii. Long-term, comprehensive market development programs coupled with substantial promotional investments were realized in 1972 as being important in obtaining greater mainland sales (Scott and Shoraka, 1974).

Guavas are also cultivated commercially in Florida, Cuba, Mexico, Venezuela, India, Pakistan and Africa. Guavas in Florida are primarily a processed and home garden fruit (Ruehle, 1959). They were first planted commercially in Florida in 1912 at Palma Sola (Ruehle, 1948). Cuba in 1944 reportedly shipped 113,000 kg of concentrated jelly base and 1.4 million kg of miscellaneous guava products (Ruehle, 1948). Uttar Pradesh is the principal growing area in India and accounts for more than half of the total area devoted to guava cultivation (Teaotia, 1967). Large areas in Western Pakistan are under guava cultivation with Punjab leading in guava production (Ahmad, 1961).

RED-BANDED THRIPS

History and distribution

The red-banded thrips (RBT), *Selenothrips rubrocinctus* Giard., is native to tropical America (Callan, 1943b; Reyne, 1921; Van Hall, 1932) with world-wide distribution. It is found in the Atlantic and Pacific islands and was unquestionably indigenous to some of these islands or possibly the West Indies. It is present between the latitudes on 30°N and S (Russell, 1912). S. rubrocinctus, infesting Psidium polycarpum growing on the sunny exposed rocks of the upper rivers of Surinam, Brazil, was considered as an original food plant (Reyne, 1921). However, cashew (Anacardium occidentalis) another preferred plant, may also be the original food plant (Urich, 1911).

RBT was a common insect species by the late 1930's in Hawaii following the first records on Oahu. Five common host plants listed by Cooper (1977) are presented in Figs. 1-6. On trees it was collected on Oahu on Mangifera indica and Calophyllum inophyllum (Sakimura and Krauss, 1937). It had a moderate host range among shrubs. This thrips, collected in Hawaii on P. guajava and Mangifera indica growing in the wild in 1937 on the island of Kauai, became a new Thysanoptera species recorded for that island (Sakimura, 1938). The occurrence of the RBT on Maui and Molokai was first recorded in 1944 on the leaves of Mangifera indica and Schinus terebinfolius. Mango leaves were heavily infested (Sakimura and Krauss, 1944). The island of Hawaii was included in the distribution range of the RBT when specimens were recovered from the leaves of azalea (Sakimura and Krauss, 1945). Eugenia uniflora was included in the Hawaiian host range of the RBT in 1939 (Sakimura, 1939). Leaves on a young tree of Syzygium cumini located on Kauai were reported severely injured in 1944 in the presence of extremely high populations. Litchi chinensis was recorded as a new host, but

PLATE I

Fig. 1. Cacao (Theobroma cacao).

Fig. 2. Cashew (Anacardium occidentale).

Fig. 3. Distal primary subvascular distribution of the RBT on leaves from the false kamani (Terminalia catappa).

Fig. 4. Mango (Mangifera indica).

Fig. 5. RBT damage on the fruit of the strawberry guava (Psidium cattleianum).

Fig. 6. Azonal distribution of the RBT on leaves from the false kamani (Terminalia catappa).


1
4
2
5
DISTAL PRIMARY
SUBVASCULAR
AZONAL
3
6

infestation was very low (Sakimura and Nishida, 1944). Mango leaves and occasionally the fruits were attacked by the RBT in the 1960's. The varieties 'Hawaiian' and 'Pirie' were commonly attacked (Yee, 1963). RBT has been recorded on guava in Florida (Smith, 1953), Puerto Rico (Dozier, 1926; Wolcott, 1948), Recife (Arruda and Arruda, 1971), Ghana (Forsyth, 1966), and in various African countries (Schmutterer, 1969).

Taxonomy, description and life history

The history of the evolution of the classification systems for the order Thysanoptera, including taxonomic works by Bagnall, Hood, Karny, Priesner and Stannard, has recently been reviewed by Ananthakrishnan (1979).

Selenothrips rubrocinctus Giard., belongs in the family Thripidae (Ananthakrishnan, 1979; Reed, 1970), a family containing most of the species in the suborder Terebrantia (Reed, 1970). According to Kurosawa (1968), the synonymy of this species includes:

Physothrips rubrocinctus Giard
Heliothrips rubrocinctus Franklin
Heliothrips (Selenothrips) rubrocincta Karny
Selenothrips rubrocinctus Hood
Selenothrips rubrocinctus Moulton
Selenothrips rubrocinctus Takahashi

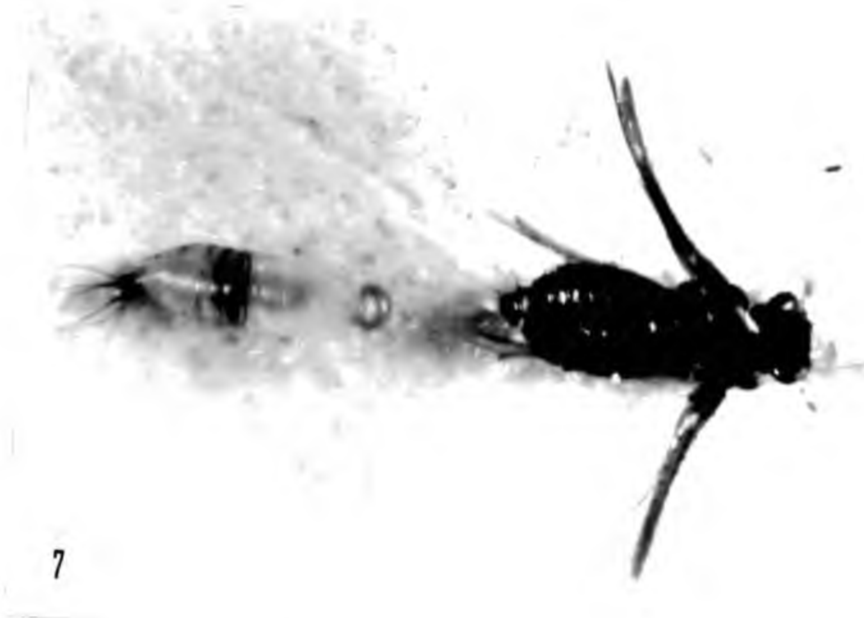
Genera in Thripidae characteristically have 6-9 antennal segments, narrow wings with apex usually pointed and is ventrally directed (Reed, 1970). Antennae of the RBT are 8-segmented (Urich, 1911; Franklin, 1909) and generally brownish. The spines and well-developed forked sense cones are located on segments 3-6 and 3-4, respectively (Franklin, 1909). Other distinguishing characters are wing veins, setae-bearing veins, maxillary stylets on the mouthcone (Ananthakrishnan, 1979), 2-segmented maxillary palpi and banding of later larval stages with a distinctive bright red hypodermal pigment across the abdominal base (Franklin, 1909). The female RBT bears a distinct sawlike ovipositor typical to the species of the Terebrantia (Ananthakrishnan, 1979; Reyne, 1921). An immature and adult RBT are shown in Fig. 7.

Fennah (1955), Reyne (1921), Urich (1911), and Cooper (1977) have described the life cycle of the RBT. The kidney-shaped eggs with translucent shell are inserted singly into the epidermis of the lower leaf surface. After laying the eggs, the female covers the oviposition puncture with a drop of excrement. Approximately 12 days later the nymphs emerge. They feed on the leaf for about 10 days and during which time they undergo two molts. The prepupal and pupal stages last approximately 24 hours and 2-3 days, respectively. The duration of the entire life cycle is about a month. Dry periods appeared to be the most favorable for development (Urich, 1911). Variations in the duration of the life cycle occurred with locality. The total life cycle in a greenhouse in Washington, D. C. varied between 28 and 43 days, while in Florida it was 20-43 days (Russell, 1912).

PLATE II

Fig. 7. Immature (left) and an adult female (right) RBT.

Fig. 8. General morphology of the anterior in the adult female RBT.



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Females are sexually mature soon after emergence and are capable of producing up to 50 offsprings during the life-span of 30-46 days (Fennah, 1955; Reyne, 1921). Males live about 39 days (Reyne, 1921). In Florida, RBT may have at least 10 generations annually (Russell, 1912).

Reproduction and dispersion

Females are predominant in a population of RBT as with most other species of Thysanoptera. Haploid males are produced by unfertilized eggs, resulting in arrhenotoky (Ananthakrishnan, 1979). The RBT reproduces parthenogenetically (Ananthakrishnan, 1979) and bisexually during certain times of the year (Russell, 1912). Copulation, lasting approximately 2-3 minutes, has often been observed in the field (Reyne, 1921). Females, which are always diploid, live much longer than do the haploid males (Ananthakrishnan, 1979).

The sex ratio of the RBT may be altered through the allelopathic properties of the host plant, which causes a differential mortality of the sexes (Callan, 1943a). Males that appear only seasonally are rare in field populations (Urich, 1911). The percentages of males were 16 times higher on cashew than on cacao, 2.23 and 0.14 percent, respectively (Callan, 1943a). During periods of severe attack, the male to female sex ratio increased to 1.5 percent from the normal ratio of 0.3 percent (Reyne, 1921).

Populations of RBT change with season. The highest population of thrips in Surinam coincided with periods of drought (Reyne, 1921). Low populations observed during the rainy season have been attributed to adverse effects on reproduction (Fennah, 1963; Reyne, 1921). Large numbers of reproducing females are destroyed in Florida by the heavy summer rains (Russell, 1912). However, at the Waimanalo Experiment Station the thrips population was not correlated with rainfall on the 132 guava trees studied or the six most highly infested trees (Cooper, 1977).

Populations of S. rubrocinctus are usually maintained at low levels by natural enemies and unfavorable conditions (Wolfenbarger, 1966). Dasyscapus parvipennis Gahan, a minute chalcid wasp (Adamson, 1936; McMurtry and Johnson, 1963) was not observed parasitizing larvae in the field. Biological control of the RBT was suggested by the common occurrence of spider webbing adjoining the interfaces of fruit clusters and leaves, which correspond to localities inhabited by the RBT. Adult (Fig. 9) and immatures of Theridion grallator were repeatedly observed nesting (Fig. 10) in the enclosure formed by the persisting, overlapping calyx lobes of young developing guava fruit. They were not commonly observed in the calyx area of mature fruit. Expansion of the calyx with a subsequent loss of the protecting lobes may account for their absence in mature fruit.

The eggs are laid singly. Each female has a normal capacity of laying 25-50 eggs, depending upon temperature. Temperature, as well as photoperiod and food, influences the duration of the life cycle

PLATE III

Fig. 9. Adult specimen of *Theridon gallator*.

Fig. 10. Mass of immatures located in the calyx of the guava fruit.

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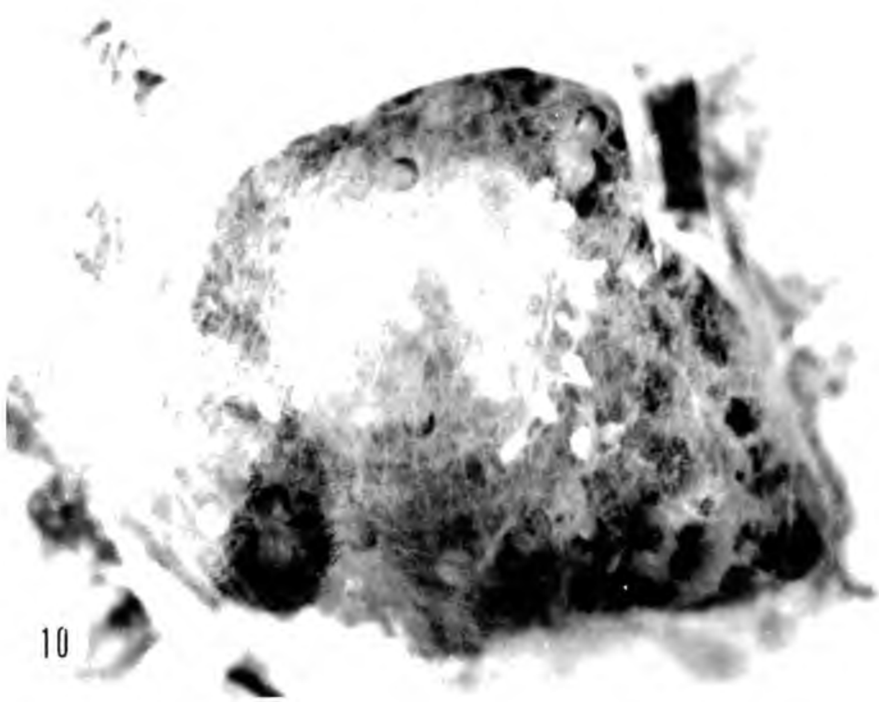

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(Ananthakrishnan, 1979). Although temperature variation can affect the activity of RBT, its abundance was not related to temperature in the field (Reyne, 1921). That temperature was not a critical factor in RBT populations in guava plantings in Hawaii was indicated by a lack of correlation between either average maximum or minimum monthly temperatures and thrips populations (Cooper, 1977). At a low temperature of 9°C the thrips become motionless. Movement slowly resumes at 17°C with normal activity at 19°C. Exposure to temperatures of 27-40°C for 1 hour resulted in death of 70-80% of the adults (Reyne, 1921).

The life cycle of many species of thrips characteristically include a period of aerial migration of predominantly sexually mature individuals from the breeding sites (Ananthakrishnan, 1979). The adults of RBT are active and highly mobile (Fennah, 1955). They appear to fly during the cool afternoon (Urich, 1911) and usually are the first to invade maturing cashew leaves (Fennah, 1963). However, the annual distributional pattern in a cacao plantation indicated a very stable rate of dispersion (Fennah, 1955). Studies on the spatial distribution of RBT in a guava seedling field revealed heavy concentrations of individuals on few trees in restricted areas indicating that the distribution was not normal. The area of highest concentration was observed to shift with time (Cooper, 1977).

Mechanism and pattern of feeding

Two piercing maxillary stylets and a short left mandible are believed to comprise the feeding apparatus of thrips (Mound, 1974; Fennah, 1963). The feeding process involves (1) laceration of the epidermal surface with the mandibles, insertion of the maxillary stylets through a round socket at the labrum apex into the deeper cell layers (Ananthakrishnan, 1961) by mechanically driving the unpaired mouthspines into the plant tissue through vertical head movement (Reyne, 1921); (2) rasping of the leaf tissues within, and (3) sucking the plant sap into the stylets. A partial vacuum is created by the dilation of the pharnynx lumen through muscular contraction (Ananthakrishnan, 1961). Probing occurs about once every second (Reyne, 1921). Plant solutes are imbibed from only the outermost cells of cashew leaves including the spongy parenchyma layers (Fennah, 1963).

Stereo-electron and scanning electron microscope studies have demonstrated that the maxillary stylets of thrips are complex structures that form a distinct feeding tube (Mound, 1971; 1974). Sections of the mouth cone indicated that the stylets are grooved, while the single mandible is a closed tubular structure (Mound, 1971). The general morphology of the head and feeding apparatus of an adult female is shown in Fig. 8.

The larvae and adults are the feeding stages and the eggs, prepupa, and pupa, the non-feeding. During the larval and adult stages, the RBT feeds 0.5 and 0.3 cm^2 of leaf surface per day, respectively (Reyne, 1921). The larvae generally feed in colonies (Urich, 1911) and cause greater damage than do the adults due to higher populations and gregarious feeding habits (Ananthakrishnan, 1971). Young RBT are 6.5 times more numerous than adults on cashew leaves (Cavalcante et al., 1975). The feeding patterns of RBT may be related to spatial or positional orientations, maturity or developmental period and/or environment. It does not feed indiscriminately on Anacardium occidentale and Theobroma cacao (Fennah, 1963). The attack on the former crop occurs in a somewhat localized and confined fashion (Bigger, 1960). Both adults and nymphs generally feed on the abaxial laminar surfaces (Bigger, 1960; Fennah, 1963; Abraham, 1958; Van Hall, 1932; Urich, 1911).

Distribution patterns on the leaf surface of RBT may be basal primary subvascular, distal primary subvascular, submarginal interveinal, peritraumatic and azonal (Fennah, 1963). Basal primary subvascular is the commonest pattern in which the individuals aggregate along the midrib and feed exclusively on the laminar tissue adjacent to the midrib. Distal primary subvascular pattern is characterized by the presence of thrips along the sides of the primary veins and along the central third of the midrib (Fig. 3). Thrips distributed distally in small groups on the lamina between the primary veins of old leaves is referred to as a submarginal interveinal pattern. Peritraumatic refers to the distribution of thrips bordering necrotic areas. Following feeding of other areas, thrips assumed an azonal distribution (Fig. 6) on the unexploited leaf areas (Fennah, 1963).

Damage to crop plants

Investigations are lacking on the precise nature and extent of damage the RBT causes to guava leaves and fruits. Fruits from highly preferred clones may have 90% of the crop damaged in the field (Nakasone, personal communication, July 1980). Severe russeting hinders accurate and precise determination of guava fruit maturity. Reduced quality of the processed puree inevitably results from harvesting unripe fruit.

Defoliation, preceded by yellowing of the leaf surfaces, was the most serious damage on cacao following severe attack (Van Hall, 1932). Dieback in cacao trees regularly follow severe attacks with 5% and higher mortality occurring in mature and young trees, respectively. Yield loss commonly amounts to 50% in badly attacked cacao fields (Reyne, 1921). Discoloration of the surface of attacked pods hampers accurate assessment of pod maturity (Van Hall, 1932; Hart, 1911).

Bigger (1960) reported the following results from his studies with cashew trees. Trees that were attacked by thrips produced 33% more flowers than the control at the peak period, but yield was reduced by 41% or about 80 kg of nuts per 100 trees. Attacked trees produced lower quality nuts that were lower in average weight than those from uninfested trees. RBT greatly reduced the number of male flowers per inflorescence and the ratio of male to hermaphrodite flowers.

Mango nurseries and groves have been afflicted (Ruehle and Ledin, 1960) by adults and larvae that mutually feed on the lower mango leaf surfaces, causing a dry browning (Moznette, 1922), silvering (Zimmerman, 1948), and defoliating (Ruehle and Ledin, 1960; Ruehle, 1966; Moznette, 1922; Wolfenbarger, 1966) syndrome of attack. Attacked fruits exhibit skin discoloration (Ruehle and Ledin, 1960; Holdaway and Nishida, 1947), russeting (Ruehle, 1966), cracking (Ruehle and Ledin, 1960; Wolfenbarger, 1966; Zimmerman, 1948) and roughening and poor quality (Holdaway and Nishida, 1947). Flesh of severely damaged mango fruits may become flabby beneath the wrinkled skin areas (Zimmerman, 1948). Percentage of injured fruits increased with the fruiting seasons, but accumulative injury sustained in late maturing varieties may have accounted for part of the variation. Thin, smooth-skinned varieties, like Hall, with a tendency of fruit clustering were most frequently attacked (Wolfenbarger, 1966). Flowering and fruit set may be reduced by severe infestation prior to bloom (Ruehle and Ledin, 1960). The noticeable reddish, globular droplets, that are carried on the stout anal hairs and excreted on the fruit surface, become hard and black (Russell, 1912). These spots detract from the appearance of the fruit (Ananthakrishnan, 1971).

Bagging and insecticide trials on grape indicated that the damage by another thrips, *Frankliniella occidentalis*, was concentrated over a two week period (Jensen, 1973). Ovipositing scars of *F. occidentalis* reduced the quality and the percentage of marketable fruits. Splitting of the skin of attacked fruits during ripening was observed in one variety (Jensen, 1968).

INSECT RESISTANCE

Integrated Pest Management (IPM)

The hazards associated with chemical control measures can be reduced by implementing IPM (Hall, 1978). Excessive use and dependence wholly upon chemical control measures and the resulting development of resistance to pesticides, rapid resurgence of target organisms, and outbreaks of secondary pests are generally regarded as the causes of the need for integrated control (Smith, 1978).

Environmental quality may be protected and preserved by reducing the excessive use of insecticides (Dahms, 1972). Without excessive use of pesticides, pest populations are maintained at relatively low and stable levels, predators and parasites of pests remain undisturbed, and phytotoxicity dangers avoided (Hall, 1978).

Phytotoxicity evaluations of 10 pesticides at various rates or combinations applied to 28 species of plants grown under 50 percent wood-lath shading, showed that guava was one of the most sensitive plants. Tip and blade burn were common symptoms (Reinert *et al.*, 1976).

History, concepts and cases of insect resistance

Insect resistance in plants has been recognized since the early 1800's (Waiss, 1977). The concept of varietal plant resistance was reverberated in the 1930's as an important preventative method of serious insect depredation (Felt and Bromley, 1931). The utilization of insect resistant plants, in combination with good cultural practices, are probably the most effective alternatives to chemical insecticides (Waiss, 1977). Cultivation of resistant plant varieties ideally protects against crop loss by insects and correspondingly prevents environmental pollution (Gallun, 1972).

Nonpreference is the expression of genetically controlled insect resistance (Gallun, 1972; Painter, 1968). Insects contacting plants with nonpreference characteristically will feed or oviposit to a lesser extent than they do on more preferred hosts. Insect populations are not reduced rapidly by this mechanism in comparison to antibiosis, which deleteriously affects the insect directly (Gallun, 1972).

Plants have either intrinsically possessed or developed survival mechanisms to arthropod attack, such as the evolution of secondary metabolic plant products that function in host plant resistance (HPR) (Waiss, 1977). Breeding programs for resistant cultivars would be greatly improved by the identification of the chemical basis of host-plant resistance. Source attractants and feeding and ovipositioning stimulants provide insects with the adaptive capabilities to their host. Often chemical and physical deterrents or the lack of feeding and ovipositing stimulants in plants culminates in nonpreference (Waiss, 1977).

Variability in host preference and feeding habits may occur among thrips species (Sakimura, 1961). Variations in resistance among plant cultivars to Thysanoptera have been recorded for onion thrips, Thrips tabaci, species with similar habits as RBT. The concept of long lasting plant resistance is exemplified by the structural leaf characters associated with thrips resistance in onions (Jones et al., 1934). Sources of resistance to thrips, aphids, leaf-miners, flea beetles and fruitworms have been located in tomatoes. Breeding for resistance to some of these pests was a real possibility (Lange and Kishiyama, 1978). It was realized early that utilization of thrip-resistant cacao could be used as a control measure in place of chemical, cultural or biological methods (Callan, 1943b).

Abundance of the RBT was found to vary with the genetic constitution of cacao. Significant differences were observed for ratings of the incidence of this pest among 199 ICS clones. Average ratings varied from below 3.0 (light) to above 6.0 (rather heavy) (Fennah, 1955).

Previous fruit preference tests have shown conflicts among the differences observed between various guava clones (Cooper, 1977). Initial tests of RBT preference for young guava fruits of 11 clones indicated that clones 180 and 157 were significantly different from the fruits of 132. Subsequent fruit tests using the commercial cultivars, 'Beaumont' and 'Ka Hua Kula', and clones 148, 157, 168 and 180 indicated that only 'Beaumont' was significantly more susceptible. Clone 157 was shown in another test to be the least preferred, while clones 168 and 180 to be the most preferred (Cooper, 1977).

Host plant selection

Almost all adult insects are free to select their food, which may be either a passive or active process (Maxwell, 1972). The ovipositing female was the key to the process of host-plant selection (Kogan, 1977).

Generally, Thysanoptera have a tendency to aggregate in small discrete favorable microhabitats within larger and more general habitat and are very susceptible to environmental changes (Ananthakrishnan, 1979).

Plant age (Reyne, 1921), environmental influences of tropism (Reyne, 1921), and/or passive selection (Fennah, 1963) may be key factors in establishing the extremely intricate association between the RBT and guava. Laboratory tests with RBT indicated that freedom from infestation of cashew was not the result of an escape mechanism nor due to deleterious effects related to toxic substances (Fennah, 1963).

Most polyphagous thrips, as well as aphids and whiteflies follow Model II-type host-selection strategy presented by Kogan (1977). Colonizing adult populations are passively directed to host plants by visual stimuli, which elicit aerial-landing. Selective probing ensues with acceptance of the host being dependent upon the presence of arrestants, and a food source that is acceptable for immatures to complete development (Kogan, 1977).

Phototaxis is pronounced in the adults of RBT with greatest disposition towards the blue and violet light. Positive reactions to light are not exhibited in larvae (Reyne, 1921). Passive host-plant selection was exemplified by RBT nymphs wandering freely, but tending to remain where they hatch (Fennah, 1963).

Carbohydrates, fats, proteins and minerals have contrarily been viewed as unimportant factors in host-location or finding. Secondary plant substances and essential oils of plants have instead been regarded as the two most important groups involved in insect behavior (Maxwell, 1972).

Associated factors

Insect distribution on cashew leaves was probably influenced greatest by localization of readily available and soluble nitrogenous constituents in the cell sap. Nitrogen was clearly important in increasing the suitability of cacao as a host of the RBT (Fennah, 1965). Cacao trees located in plots receiving nitrogen were significantly more severely attacked than those in the non-treated plots. Adverse foliar constitution, induced by the environment, may explain the failure of colonization of cacao leaves produced from particular flushes (Fennah, 1955). Quantities of the various nitrogenous components present and the physiological age of the tissue were the more important predetermining susceptibility factors than the total amount of N in the leaf. The dry matter and total nitrogen content broadly reflects the physiological age of leaves. Young tissue tends to have a low dry weight to fresh weight ratio in combination with a high N content, while the reverse ratio is true in the case of old tissue (Fennah, 1965).

Relative imbalances of N in relation to other elements may provide conditions favorable for infestation, although the supply of N is adequate (Fennah, 1955). Cacao trees severely attacked by RBT had a relatively high N to K leaf ratio in the young leaves. Susceptibility to the cacao thrips attack may be reduced by lowering the N to K ratio, which was suggested as a useful index of the physiological condition of cacao in relation to susceptibility to attack by thrips (McDonald, 1932).

Water and solar radiation appeared to be other factors associated with thrips infestation. Discs taken from cacao leaves exposed to full sunlight were lower in total N and deteriorated faster, than discs from leaves receiving 25% sunlight (Fennah, 1965). Severe attack was observed on the unshaded leaves (Fennah, 1955). The succulent apical leaves of cacao are generally uninfested by RBT, while fully hardened leaves of the previous flush are heavily attacked. Infestation steadily declines on leaves of subsequently older flushes and is lacking on leaves of the flush occurring at the onset of the wet season. This thrips is commonly distributed in epitraumatic and peritraumatic patterns on cacao leaves, which correspond to injured areas that are usually under an abnormally high water stress (Fennah, 1965).

Maturity of cacao pods appeared to be related to thrips infestation. Young cacao pods are rarely attacked, while thrips abundance was more likely about five months following fruit set (Fennah, 1955; 1965).

Structural differences have resulted in preference variations of various plants. The under surfaces of the leaves of *Persea gratissima* and *Terminalia capatta* are less preferred due to the waxiness and hairiness of the respective leaf surfaces (Reyne, 1921). The mechanism of resistance in cacao leaves was considered to be related to puncture-resistance (Callan, 1943b). Preference for the morphologically abaxial surface of cashew did not result from physical deterrents in the adaxial surface or protection offered by the abaxial veins (Fennah, 1963).

Genetic variations in nutrient content and alterations of susceptibility

Varietal difference in K concentration and total K uptake into the plant has been confirmed in three tomato varieties with regards to incidence of blossom-end rot (Besford, 1978). Early corn nutrition research showed that when one parent or line exhibited the capacity to produce good growth and absorb P with relatively low amounts of available P, the F_1 crosses performed at least as well as the better parent. A characteristically high ratio of secondary to primary roots was inherited in the P-efficient lines or crosses (Smith, 1934). Significant differences in K, CA and MG concentration of nonvernalized wheat tissue have been found among three wheat cultivars with respect to grass tetany. The development of wheat cultivars with increased balancing of the cation composition appeared attainable through breeding programs (Karlen et al., 1978). Fruit from five rabbiteye blueberry (Vacciinum ashei Reade) cultivars had significant differences in their elemental composition (Dekazos, 1978).

Wide element differences also exist between and within species (Munson and Nelson, 1973). Five tomato strains were genetically linked to K content, which varied from 3.93 to 5.07 percent (Harvey, 1935).

Potassium application to peach trees was positively related to peach flesh resistance to browning (Cummings and Reeves, 1971). Seedlings from a resistant sorghum (Sorghum bicolor Moench) selection (KS 30) grown in excess potassium solution possessed the highest combined antibiosis and tolerance to the greenbug (Schizaphis gramianum) in comparison with susceptible plants (RS 671) under three temperature regimes. At low temperatures (21.1 to 10.0°C) damage in normally resistant plants increased to levels of the susceptible line when K was deficient. A high temperature interaction was expressed by the resistant line, indicating that tolerance was somewhat unstable upon alteration of these factors (Schweissing and Wilde, 1979).

Bitter pit incidence and protein N level in 'Merton Morcestor' apple both were increased by increasing the supply of K. Seasonal differences were noted in the response of cultivars and the interrelationship among fertilizer levels and susceptibility to bitter pit incidence (Lewis et al., 1977).

The relative magnitude of the K to CA ratio within a potassium fertilizer treatment was found to be related to the incidence of blossom-rot (Besford, 1978). Increasing the K to CA ratio between 0.04 to 0.29 markedly decreased the color ripening disorders of tomato grown in culture solution (Van Lune and Van Goor, 1977).

Nitrate uptake and translocation can be markedly stimulated by K ions. Barley plants receiving K^+ contained more NO_3^- in the roots and shoots and had a higher nitrate reductase activity in shoots than plants receiving no K^+ (Blevins et al., 1978). Epidermal, guard, cortical and pith cells of buckwheat plants grown in the absence of potassium diminished in size, while the leaf epidermis of beets aged prematurely (Lutman, 1934).

Thus the dependence upon insecticides in regulating pest populations can be reduced by utilizing variations in host preferences, environmental influences on insect behavior and genetic controls of nutrient content in plants.

MATERIALS AND METHODS

COMPARISONS OF RUSSETED AND UNDAMAGED FRUITS FROM CLONE 157

Russeted and undamaged fruits were collected from clone 157 located at the Waimanalo Experiment Station on October 4, 1979 for analysis of soluble solids, total titratable acidity and pH of the puree.

Approximately 33 kg each of severely damaged and normally mature fruits were minced and separately passed through a pulper fitted with a 0.102-cm diameter screen to remove seeds. Puree samples were frozen in covered 100 ml pyrex glass beakers at 0°C for later analyses. Average total soluble solids readings were determined on the filtrates of the respective thawed purees using an Atago (0-31%) refractometer. Three separate filtrations were used to obtain an average measurement. Total acidity was determined by titration to pH 8.1 with 0.1 N NaOH using phenolphthalein as a color indicator. Additional samples were thawed for pH determinations on a Beckman Model 3550 digital pH meter by placing the probes directly into the puree.

Sections approximately 1 x 1 mm in size were excised from the equatorial axis of a severely russeted and undamaged fruit. The selected tissues were promptly preserved in FAA killing and fixing solution (Johansen, 1940). Transverse sections were made from processed and embedded tissue at 10u, stained in toluidine blue O (Sakai, 1973) and mounted in resin. Photomicrographs were taken with an Exa camera mounted on an Olympus microscope.

EVALUATION OF RBT PREFERENCE AMONG VARIOUS *PSIDIUM* GENOTYPES AND THE RELATIONSHIP OF FRUIT PARAMETERS TO PREFERENCE

Field Procedures

Four replications of six clones, 143, 156, 157, 168, 180 and 'Beaumont', were used in augmentation with the following eight unreplicated guava accessions: 'Allahabad Safeda', 'Burma', 'Hong Kong Pink', 'Lucknow-49', 'Patillo', 'Pink Acid', *P. guineense* x *P. guajava*, and Ruby x Supreme.

One fruit was selected from each of the respective trees located at the Waimanalo Experiment Station on 10 sampling dates, placed into marked bags and brought to the laboratory in a foam container for preference tests and analyses of selected fruit parameters.

Female adults of RBT collected in the field on immature fruits of *Macadamia integrefolia* were used to study the preference mechanism. The adult insect is the determining entity in host plant selection (Parrott *et al*., 1978).

Laboratory Methods

Each fruit selected from the respective trees spaced approximately represented a replication and was used for all tests. The fruits were rinsed in deionized water, air dried, and fruit firmness measured. Fruits were then halved with a stainless steel knife. One half of each fruit was used in the preference test, and the other half was used to obtain measurements on length, width, soluble solids, moisture and provide material for tissue analysis.

1. <u>Fruit Preference Test</u>

The fruit halves were randomly placed in the preferences cages. Each of the four cages or replications contained eight fruit-halves that were positioned on moistened Whatman filter paper (27.0 cm) so as to be approximately 5.8 cm from the center of the cage. The length, width and height of the cage were 37 x 27 x 16.5 cm, respectively (Fig. 11). Eighty adult female thrips were transferred into each preference cage by first aspirating them into a removable glass container, 2.3 cm in diameter and 2.8 cm high. The container was then placed in the center of the preference cage, which was promptly covered with a lid and sealed with masking tape along the edges. This method provided thrips equal access to the fruit surfaces of the various genotypes. Nylon organdy was used to cover the 24 x 34 cm opening and condensation of water given off by fruit respiration was prevented. Lewis (1973) stated that restricted air movement may cause condensation on the cage walls to which thrips often stick and die.

The cages were placed under a fluorescent lamp covered with green cellophane to provide a uniform but reduced light intensity. Fourteen hours later the number of thrips on each fruit was recorded. The quantitative measurement of preference was defined as:

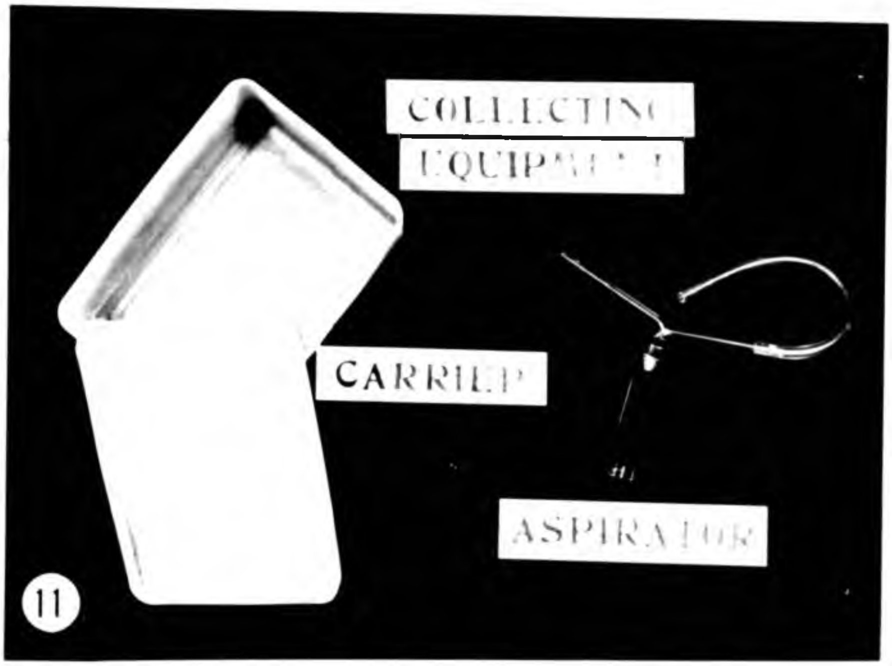
$$\%\ \text{RBT Response} = ar / n \times 100$$

Where ar = number of adults recovered on each fruit, and n = total number of thrips released in each cage.

PLATE IV

Fig. 11. Carrier and aspirator with removable collecting chamber.

Fig. 12. Preference cage and nylon-organdy lid.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Measurements of percent insect response were transformed into insect ratings composed of five classes or index values. Ratings were included to provide a descriptive method of evaluating preference where: 1 = highly nonpreferred (0-2.49% response); 2 = nonpreferred (2.50-6.29% response); 3 = moderately preferred (6.30-9.99% response); 4 = preferred (10.0-13.79% response) and 5 = highly preferred (13.80% or more response.

2. Fruit Analysis of Selected Parameters

i. Fruit Firmness

A manual fruit pressure tester (Hunter Spring L-30) equipped with a cone-type attachment was used to measure fruit firmness (Fig. 14).

ii. Length and Width

Length (L) and width (W) measurements of fruits were obtained using a caliper (Fig. 14).

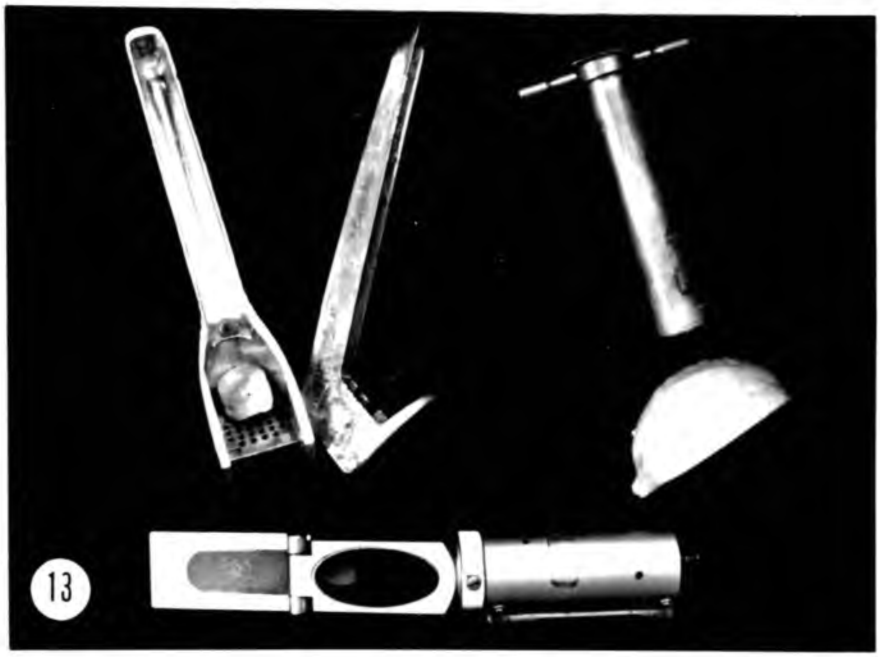
iii. Soluble Solids

Various sugars represent the greater proportion of the soluble solids in guava fruits (LeRiche, 1951). An Ekco^R garlic press was used to squeeze the juice from a fruit core (19 mm in diameter) taken at the middle of the guava fruit (Fig. 13). Estimates of the sugar content in guava fruits were obtained fromthe refractometric dry solids (SS) of the fruit juice using an Atago (0-32%) refractometer. Fruit juices generally contain refractive indexes near that

PLATE V

Fig. 13. Devices used in measuring soluble solids; press (left), cork bore (right), and Atago refractometer (middle).

Fig. 14. Devices used in measuring fruit firmness and dimensions; caliper (left), fruit firmness tester (right) and cone-type attachment (middle).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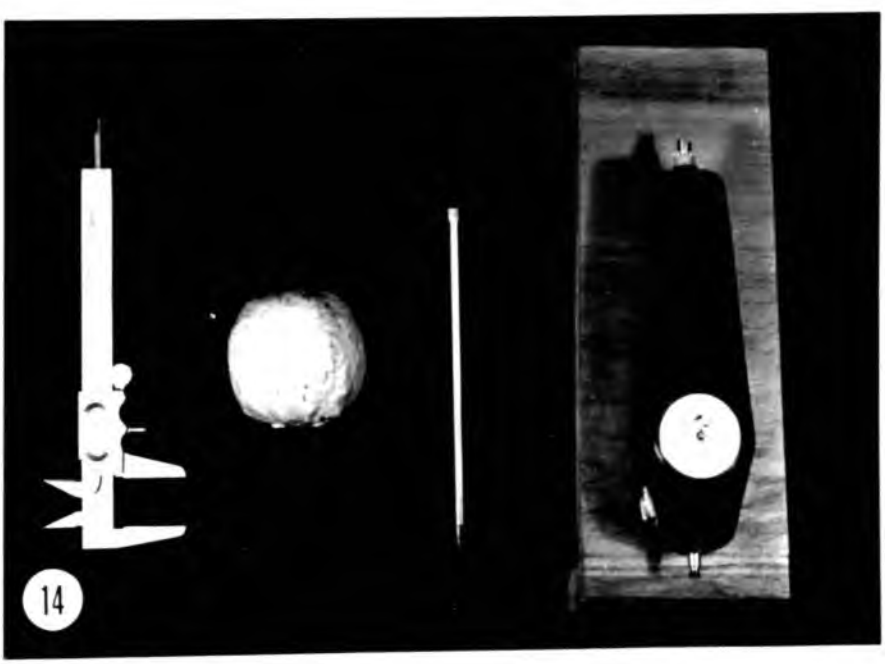
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of sucrose, where by the soluble solids content is closely approximated (Dupaigne, 1961).

iv. Moisture Content

Fresh weight (FW) was recorded for each fruit half prior to drying at 60°C in a 60 x 15 mm pyrex glass dish. Dry weight (DW) was recorded one week later. Percent moisture content (M) was derived from the following proportion:

$$\frac{FW - DW}{FW} \times 100 = M$$

v. Tissue Analysis

Dried fruit quarters were cracked using a modified vise-grip and ground to 20 mesh on a Wiley mill for chemical analysis from which percent nitrogen (N), phosphorus (P), potassium (K), calcium (CA), and magnesium (MG) was obtained.

1. Determination of Nitrogen (N)

Nitrogen of guava fruit was analyzed following a procedure used in turf analysis (Fujimoto, 1979) that employed a modified and rapid Kjeldahl procedure (Van Lieprop, 1976), a concentrated H_2SO_4 digestion mixture (Schuman, 1973) and colorimetrically assaying (Cataldo *et al.*, 1974) for ammonia on a Unicam SP 1800 ultraviolet spectrophotometer at 625 nm. The 50 mg samples were digested at 300°C to clarification or about 3 hours. The top of each 50 ml Folin-Wu tube was covered with a pyrex glass funnel after 20 min. to allow refluxing during digestion.

Dilutions of a 1250 ppm stock solution of $(NH_4)_2SO_4$ were used as standards.

2. Determination of Potassium (K), Calcium (CA), Magnesium (MG) and Phosphorus (P) in Guava Fruits

Preliminary determination of the percent K in guava fruits using a Beckman flame photometer on samples extracted with deionized water (Fujimoto, 1979) yielded erratic and inflated results. The unsatisfactory findings may have been due to Na interferences (Rich, 1965).

Alternatively, potassium, calcium, magnesium and phosphorus were determined by dry ashing the ground fruit tissue following procedures provided by Deputy (Personal communication, 1979), which were similar to Allen *et al*. (1974). Samples of the respective *Psidium* genotypes from consecutive dates were composited by pairs due to limitations of available laboratory materials and facilities. This compression of sampling dates reduced the original number from ten to five and increased the amount of sample available for analysis. a 0.5 g portion of the dried and ground fruit tissue was ashed overnight at 500°C in a porcelain crucible, cooled, moistened with a few drops of deionized water, solubilized with 5 ml 5N HCl, warmed on a hotplate for 10-15 min, and decanted into a 50 ml Folin-Wu tube. The sample was rinsed three times from the crucible into the tube, which subsequently was brought up to a volume of 25 ml, mixed on a vortex mixer and transferred to a tall glass bottle and capped.

K, CA and MG were analyzed by the U.H.-Botany Dept. using atomic absorption spectroscopy. Calcium and magnesium were determined on 10:1 dilution of the original 25 ml diluted sample with 0.555% La in 1N HCl, while K was determined on the original dilution. Determination of P was based on the analysis of the original diluted sample using a Technicon Auto Analyzer^{R}.

INFLUENCE OF K FERTILIZATION ON RBT PREFERENCE FOR CLONE 143, 157, 180 AND 'BEAUMONT' AND THE RELATIONSHIP OF FRUIT PARAMETERS TO PREFERENCE

These tests were conducted in 1979 at the Waimanalo Research Station in the field designated J-1 on Waialua clay soil (pH 6.2) with 2-6% slope (Foote, 1972). A split-split plot design was used with 4 clones, 2 K levels, 4 replications and 7 dates of sampling.

On February 1 and March 1, 1979, following the emergence of new vegetative shoots, 70 g N and 70 g P were evenly distributed by applying sulfate of ammonia (21-0-0) and treble superphosphate (0-46-0) in the furrows on both sides of each tree followed by incorporation and irrigation. The randomly allocated potassium subplot treatment consisted of an adequate amount of potassium (100 g K per tree) and a check (0 g K). Muriate of potash (0-0-61), was applied to the foliage on the two respective dates.

A moderate level of potassium (575 g K per tree) was distributed on June 7, 1979 at about the beginning of flowering in the furrow and incorporated. The modification of K application from a foliar to soil-type amendment was undertaken to prevent interferences in the preference tests that may be attributed to residual K fertilizer.

Additional nitrogen (190 g N) and phosphorus (190 g P) were applied at this time to each tree. Three months later another increment of potassium (575 g K/tree) was applied on September 9, 1979 to the subplots previously treated with muriate of potash.

Laboratory Procedures

Handling and analyses of fruits selected from each of the respective trees on seven different dates followed the procedures already described. The following fruit parameters were measured: PREF, L, W, M, PRES, SS, N, P, K, CA and MG.

Monitoring N and K Levels in Guava Leaves

Preliminary investigations on nitrogen (N) and potassium (K) in guava leaf tissue were made in June, July and August of 1978. Beginning February 1979, a bimonthly program was initiated to monitor N and K concentrations in leaf tissues of clones 143, 157, 180 and 'Beaumont'.

The index tissue for leaf analysis of guava was determined to be leaves of 4-8 months old from the third or fourth whorl of nonfruiting shoots (Singh and Rajput, 1978). A leaf from the third whorl was selected in these tests from 15 nonfruiting branches around each tree. Leaf samples were rinsed in deionized water, dried at 60°C, and ground to 40 mesh on a Wiley mill.

1. K and N Analysis

A water extraction method (Fujimoto, 1979) was adopted for K analysis of leaf tissue. Percent transmission readings of the prepared samples were determined using a Beckman (Model B) flame-photometer set at 766 nm. The method of N analysis of leaves followed the procedures already described.

EFFECT OF K LEVELS ON CLONES 180, 157 AND 'BEAUMONT' GROWN IN CONTAINERS AND THE RELATIONSHIP OF FRUIT PARAMETERS TO PREFERENCE

Container Procedures

These tests included clones 180, 157 and 'Beaumont', which were propagated from cuttings taken from 11-year-old trees located in field J-1. Cuttings were rooted under mist in vermiculite and transplanted on February 21, 1978 into individual containers using vermiculite as the growing medium. On April 25 the rooted cuttings were transferred to .004 mil polyethylene bags, 17.5 x 12.5 x 30.5 cm. A soil:woodshaving mixture in the proportion of 2:1 was used. On May 2, 1978 the cuttings of the respective clones were moved from the Mid-Pac nursery area to the Upper Campus Facilities where they were arranged in a randomized block design.

On January 7, 1979 the plants were uniformly pruned to 25 cm high. They were repotted into black No. 3 polycans (approximately 8.2 l capacity) using about 5.0 l of an equal mixture of pea-gravel, Waialua clay soil, peat and woodshavings. Drip irrigation was installed on March 15, 1979, replacing manual watering.

The clones were organized into a split-split plot design containing 4 replications with 3 levels of muriate of potash (0-0-61) supplied at the rates of 0, 3, 0 g K per 200 ml water. Sulfate of ammonia (21-0-0) and treble superphosphate (0-46-0) were applied at a rate of 1 g each of N and P, applied together in 200 ml of water per plant. All treatments were applied at approximately four week intervals.

Laboratory Procedures

A fruit was selected from each of the respective pots on August 8 and 22, 1979. Fruit preference tests were conducted using procedures cited in the previous sections.

STATISTICAL ANALYSES

Analyses of variance (ANOVA) and Duncan's multiple range tests (DMR) were used to determine differences among the parameters measured in the three experiments. These statistics were calculated on the IBM 370 located at the UH Computer Facilities using SAS programs.

Evaluation of *Psidium* Genotypes

Two different approaches were used to evaluate the *Psidium* genotypes. Mean comparisons in the DMR were first made for each parameter among the replicated selections. Subsequently, the performance of the unreplicated accessions were accessed by mean comparisons to the replicated entries utilizing a different standard error (Brewbaker, personal communication, October 1979; Federer, 1956).

Simple linear regression analyses were used to relate TPREF; where TPREF = arcsin / % RBT recovery, with the fruit parameters, L, W, M, SS, PRES, N, P, K, CA and MG. These statistics were calculated on the IBM using procedures from SAS and BMDP programs. Bulking of fruit samples for tissue analysis necessitated calculating means for TPREF, PREF, L, W, SS and M over pairs of consecutive dates prior to analysis.

Multiple regression analyses were performed to determine if preference was explained by various factors. A stepwise procedure was used to enter the highly correlated variables with preference into the equation. The F ratio and R^2 value were used to determine the significance of the regression and estimate the percent variation obtained by the equation, respectively.

Influence of K Fertilization on RBT Preference

Split-split plot analyses were used to evaluate the influence of K fertilization on RBT preference for fruits grown under field and nursery conditions. Mean values of the parameters were separated by DMR. Simple linear and multiple regression analyses were calculated in the manner previously described.

RESULTS AND DISCUSSION

COMPARISONS OF RUSSETED AND UNDAMAGED FRUITS FROM CLONE 157

Russeted guava fruits had a comparatively greater percent of soluble solids and total acidity than undamaged fruits from the same tree, while pH did not vary noticeably (Table 1). Puree processed from russeted fruits appeared muddy-pink in color.

TABLE 1. Comparison of russeted and undamaged guava fruits.

Clone 157	Soluble Solids (%)	Total Acidity (%)	pH
Undamaged	9.3	1.71	3.08
Russeted	13.3	2.35	3.05

Scarred 'Thompson Seedless' grape (Vitis vinifera L.) berries resulting from feeding and ovipositing by the western flower thrips, Frankliniella occidentalis (Pergande) had an increase in the ^{o}Brix from 17.6 $\pm$ 1.5 to 21.5 when compared to the unscarred fruit (Yokoyama, 1979).

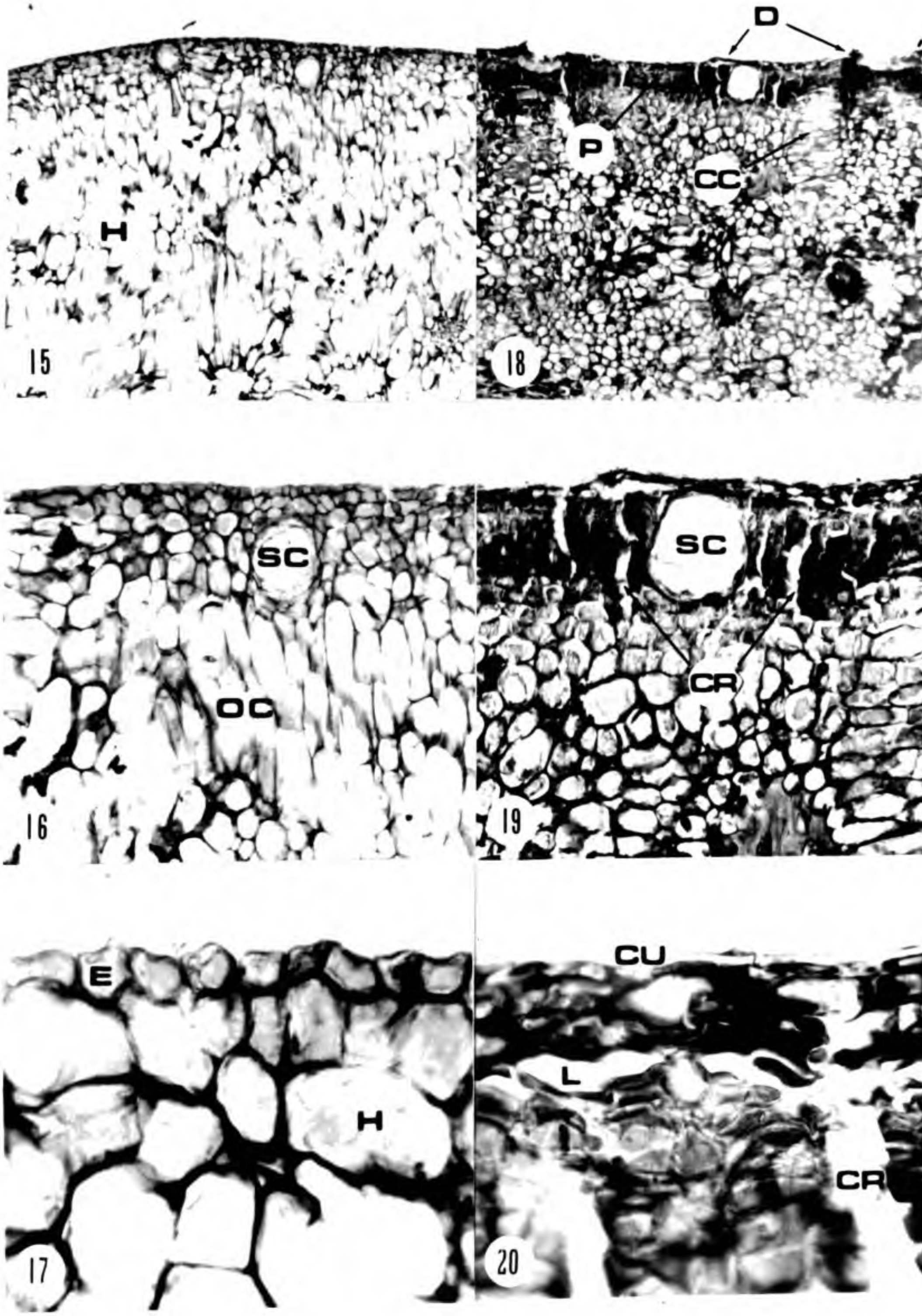
Anatomical aspects of normal and completely russeted fruits of clone 157 selected at the mature-green stage are shown in Figs. 15-17 and 18-20, respectively. Large, globular and uncompressed hypodermal cells adjoined the outer cortical cells (OC) of normal

PLATE VI

Figs. 15-17. Histological sections of the undamaged fruits of clone 157.
Fig. 15, X 60; Fig. 16, X 160; Fig. 17, X 800.

Figs. 18-20. Histological aspects on the russeting of guavas from clone 157 induced by damage from the red-banded thrips.
Fig. 18, X 55; Fig. 19, X 150; Fig. 20, X 630.

D, Epidermal disruption; CC, Cortical compressions; CU, Cuticle; CR, Crack; E, Epidermis; H. Hypodermis; L, Lacunae; OC, Outer cortex; SC, Secretory cell.


H
15
D
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fruits, as shown in Figs. 15 and 16. Epidermal (E) and secretory cells (SC) of normal guava fruits lacked disruptions or irregularities (Figs. 16 and 17).

Disruptions (D) in the epidermis were recorded in guava fruits with russeting, together with malformation of secretory cells (SC) (Figs. 18-19). Some compression (CC) in the outer cortical region is shown in Fig. 18. Similar disruptions, compressions and proliferations have been reported for apples and grapes with russeting or scarring (Simons, 1965; Simons et al., 1971; Yokoyama, 1979).

Development of a periderm (P) in guava fruits was possible (Fig. 18), but distinct phellogen, phellem and phelloderm layers were not separable. Layers of phellem, phellogen and phelloderm have been observed in apples following mechanical or freeze damage (Simons, 1969; Simons and Chu, 1978; Tukey, 1959).

A distinguishable hypodermal region was lacking in the vicinity of the darkly staining region adjacent to the secretory cells (Fig. 19). This region was noticeably disorganized and exhibited compression. Lacunae (L) were observed in association with epidermal cracks (CR) that extended into the outer cortex of the guava fruits (Figs. 18-20).

Skin-cracking, complete tissue separation between the outer cortex and hypodermis, and development of large lacunae have also been observed in fruits from various apple cultivars (Faust and

Shear, 1972; Meyer, 1944; Simons, 1969; Simons and Aubertin, 1959; Simons and Chu, 1978).

EVALUATION OF PREFERENCE AMONG VARIOUS PSIDIUM GENOTYPES AND THE RELATIONSHIP OF FRUIT PARAMETERS TO PREFERENCE

'Beaumont' was the least preferred replicated genotype over 10 sampling dates in 1979 (Table 2). An average preference rating of 2.6 for this cultivar indicated that it was a nonpreferred to moderately preferred genotype. Although preference for clone 180 was statistically comparable to 'Beaumont', it was not significantly different from the preferred to moderately preferred selections 143, 156, 157 and 168.

Fruit length (L), width (W), moisture content (M), soluble solids (SS), fruit firmness (PRES), and percent content of nitrogen (N), potassium (K), phosphorus (P), calcium (CA), and magnesium (MG) varied significantly with different replicated *Psidium* genotypes (Tables 3 and 4).

'Beaumont' fruits had the highest measurements of L and N, while fruit width and firmness were lowest. High values of M, SS and K were observed for fruits from this clone and low amounts of MG and CA.

Fruits produced on 'Allahabad Safeda' were the least frequently preferred in the set of comparisons between the six replicated clones to the eight unreplicated *Psidium* genotypes (Table 5). Ruby x Supreme was also a weakly preferred clone. This was in contrast to the preferred interspecific *Psidium* cross, *P. guineense*

TABLE 2. Mean comparison of % RBT response (PREF) and insect rating (RATE) among six replicated *Psidium* genotypes over 10 dates in 1979.*

Replicated selections	PREF (%)	RATE[u]
143	8.7a	3.2a[w]
156	9.2a	3.2a
157	11.7a	3.9a
168	9.2a	3.2ab
180	6.8ab	3.0 b
'Beaumont'	6.5 b	2.6 b

*Means with the same letter are not significantly different, 5% level.

[u]Rating scale measured from 1 = highly nonpreferred, to 5 = highly preferred.

[w]$s_{\bar{x}} = 0.286$

TABLE 3. Mean comparison of fruit length (L), width (W), moisture content (M), soluble solids (SS) and firmness (PRES) for six replicated *Psidium* genotypes over 10 dates in 1979.

Replicated selections	L (cm)	W (cm)	M (%)	SS (%)	PRES (lb)
143	5.54 b[v]	4.82a[w]	72.78abc[x]	9.56a[y]	20.85 bc[z]
156	5.35 bcd	4.83a	74.52a	8.76 b	20.74 bc
157	5.25 d	4.92a	71.11 c	7.82 c	21.34ab
168	5.30 cd	4.96a	72.07 bc	9.18ab	23.48a
180	5.49 bc	4.79ab	71.82 bc	8.73 b	23.31a
'Beaumont'	5.84a	4.76 b	73.76ab	9.64a	18.96 c

*Means with the same letter are not significantly different, 5% level.

$^{v}s_{\bar{x}} = 0.0776$ $^{w}s_{\bar{x}} = 0.0631$ $^{x}s_{\bar{x}} = 0.660$ $^{y}s_{\bar{x}} = 0.234$ $^{z}s_{\bar{x}} = 0.756$

TABLE 4. Percent nutrient content of nitrogen (N), phosphorus (P), potassium (K), calcium (CA) and magnesium (MG) in guava fruits sampled from 6 replicated *Psidium* genotypes over 5 pairs of consecutive dates in 1979.*

Replicated selections	Percent Nutrient Content				
	N	P	K	CA	MG
143	0.838 b[v]	0.200a[w]	1.701ab[x]	0.120a[y]	0.111a[z]
156	0.780 b	0.190ab	1.588 bc	0.101 b	0.100ab
157	0.812 b	0.171 c	1.616abc	0.112ab	0.099ab
168	0.641 c	0.173 c	1.545 c	0.085 c	0.094 b
180	0.825 b	0.172 c	1.654abc	0.065 d	0.101ab
'Beaumont'	1.103a	0.180 bc	1.713a	0.073 cd	0.092 b

*Means with the same letter are not significantly different, 5% level.

$^{v}s_{\bar{x}} = .0368$ $^{w}s_{\bar{x}} = 0.0395$ $^{x}s_{\bar{x}} = .00557$ $^{y}s_{\bar{x}} = 0.00520$ $^{z}s_{\bar{x}} = 0.00458$

TABLE 5. Comparison of % RBT response (PREF) and insect rating (RATE) among 14 *Psidium* genotypes over 10 dates in 1979.*

Genotypes	PREF (%)	RATE[x]
143	8.7abc	3.2ab[w]
156	9.2abc	3.2ab
157	11.7a	3.9a
168	9.2abc	3.2ab
180	6.8abcd	3.0abc
'Beaumont'	6.5abcd	2.6abc
'Allahabad Safeda'	2.7 d	1.6 c
'Burma'	5.3abcd	2.5abc
'Hong Kong Pink'	5.1abcd	2.5abc
'Lucknow-49'	4.1 bcd	2.2 bc
'Patillo'	10.2ab	3.5ab
'Pink Acid'	5.9abcd	2.5abc
P. guineense x *P. guajava*	12.0a	3.8a
Ruby X Supreme	3.2 cd	2.0 bc

*Means with the same letter are not significantly different, 5% level.

[x]Rating scale measured from 1 = highly nonpreferred, to 5 = highly preferred.

[w]$s_{\bar{x}}$ = 0.474

x P. guajava and clone 157, which were rated 3.8 and 3.9, respectively.

No significant differences in preference were observed between clones 143, 156, 168, 180, 'Beaumont', 'Burma', 'Hong Kong Pink', 'Lucknow-49', 'Patillo' or 'Pink Acid'. Preference ratings (RATE) ranged between 3.5 to 2.2 for 'Patillo' and 'Lucknow-49', respectively.

Fluctuations in the comparative mean response of preference over five combined dates of sampling for a preferred (157), intermediate ('Beaumont'), and a nonpreferred ('Allahabad Safeda') genotype are presented in Fig. 21. Preference for 157 remained at a high level on all sampling dates without noticeable fluctuations, while an increasing trend in preference was observed for 'Beaumont'. Lowest preference over all sampling dates was observed for fruits from 'Allahabad Safeda'.

Data on fruit parameters and nutrient contents for the replicated and unreplicated genotypes are presented in Tables 6 and 7. Differences for all of the parameters were significant between these genotypes. Selection 143 had longer fruits with greater P and CA values than many of the genotypes. Fruits of this genotype were intermediate in W, M, N, K, and MG, while PRES was somewhat low.

Moisture content was highest in clone 157 and lowest in 'Pink Acid'. Low PRES and K values were recorded with guavas from the former clone.

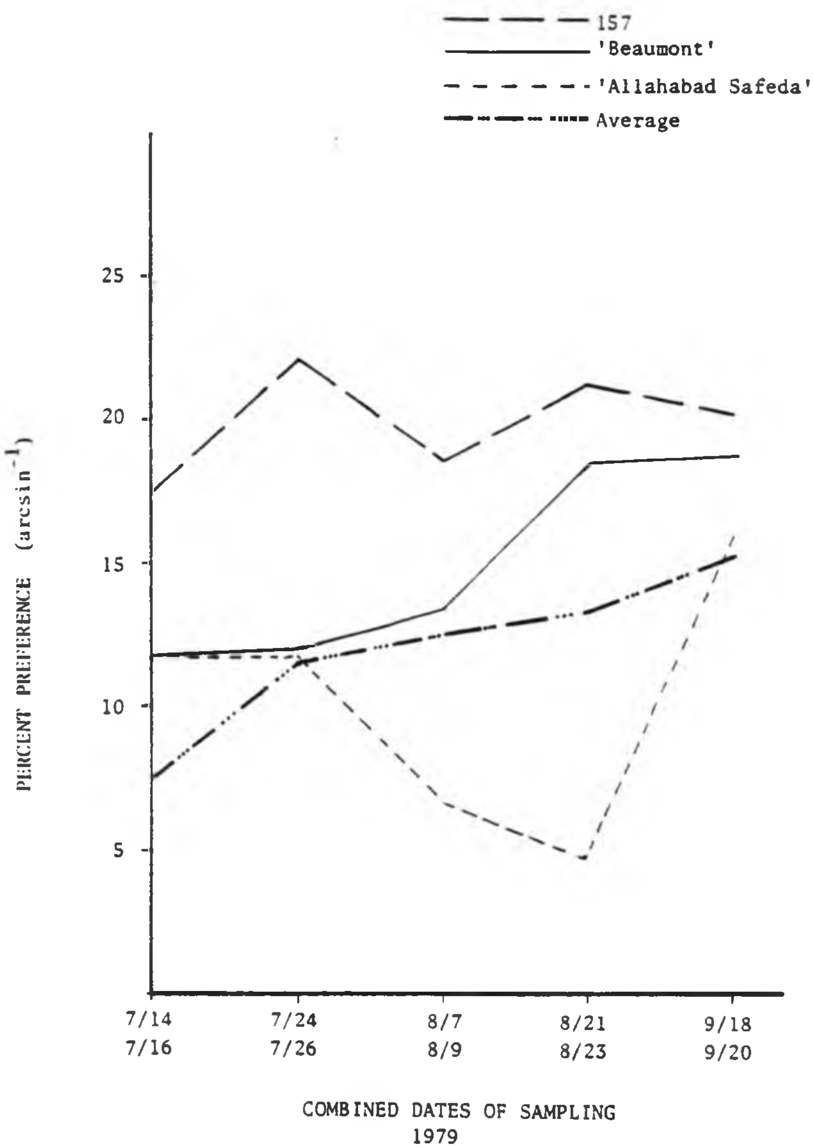

Figure 21. Comparative mean response of preference for three clones over five combined dates of sampling in 1979.

TABLE 6. Comparison of fruit length (L), width (W), moisture content (M), soluble solids (SS) and firmness (PRES) of guava fruits from 14 Psidium genotypes sampled over 10 dates in 1979.*

Genotypes	L (cm)	W (cm)	M (%)	SS (%)	PRES (lb)
143	5.54abc[v]	4.82abcd[w]	72.78abc[x]	9.56abcd[y]	20.85 bcd[z]
156	5.35 bcd	4.83abcd	74.52a	8.76ab	20.74 bcd
157	5.25 bcd	4.92abc	71.11abc	7.82 d	21.34abcd
168	5.30 bcd	4.96ab	72.07abc	9.18abc	23.48abc
180	5.49abc	4.79 bcd	71.82abc	8.73abcd	23.31abc
'Beaumont'	5.84a	4.76 bcd	73.76a	9.64ab	18.96 d
'Allahabad Safeda'	5.21 cd	5.13a	70.13 bc	8.20 cd	25.08a
'Burma'	4.59 e	4.61 cd	71.48abc	9.03abcd	22.71abcd
'Hong Kong Pink'	4.98 d	4.63 bcd	71.62abc	10.01a	23.64abc
'Lucknow-49'	4.52 e	4.24 e	72.94ab	9.04abcd	21.67abcd
'Patillo'	5.48abc	4.76 bcd	69.68 bc	9.98a	21.15abcd
'Pink Acid'	5.35 bcd	4.51 de	69.31 c	9.42abc	24.16ab
P. guineense x P. guajava	5.66ab	4.76 bcd	74.45a	8.45 bcd	19.81 cd
Ruby x Supreme	5.53abc	4.90abc	69.46 bc	8.94abcd	23.89ab

*Means with the same letter are not significantly different, 5% level.

$^{v}s_{\bar{x}} = 0.129$ $^{w}s_{\bar{x}} = 0.105$ $^{x}s_{\bar{x}} = 1.094$ $^{y}s_{\bar{x}} = 0.388$ $^{z}s_{\bar{x}} = 1.254$

TABLE 7. Percent nutrient content of nitrogen (N), phosphorus (P), potassium (K), calcium (CA) and magnesium (MG) in guava fruits sampled from 14 *Psidium* genotypes over 5 pairs of consecutive dates in 1979.*

Genotypes	Percent nutrient content				
	N	P	K	CA	MG
143	0.838 bcd[v]	0.200ab[w]	1.701abc[x]	0.120ab[y]	0.111ab[z]
156	0.780 cd	0.190ab	1.588 cd	0.101abcd	0.100abc
157	0.812 bcd	0.171 b	1.616 bcd	0.112abc	0.099abc
168	0.641 d	0.173 b	1.545 cd	0.085 cdef	0.094 bc
180	0.825 bcd	0.172 b	1.654 bc	0.065 f	0.101abc
'Beaumont'	1.103a	0.180ab	1.713abc	0.073 f	0.092 bc
'Allahabad Safeda'	0.859 bc	0.186ab	1.891a	0.084 def	0.094 bc
'Burma'	0.845 bcd	0.191ab	1.677 bc	0.125a	0.122a
'Hong Kong Pink'	0.769 cd	0.176ab	1.616 bcd	0.098abcde	0.111ab
'Lucknow-49'	1.000ab	0.194ab	1.657 bc	0.120ab	0.120a
'Patillo'	0.740 cd	0.176ab	1.643 bc	0.089 cdef	0.114ab
'Pink Acid'	0.734 cd	0.186ab	1.725abc	0.093 bcde	0.104abc
P. guineense x *P. guajava*	0.822 bcd	0.187ab	1.417 d	0.104abcd	0.083 c
Ruby x Supreme	0.821 bcd	0.205a	1.810ab	0.079 def	0.119a

*Means with the same letter are not significantly different, 5% level.

$^{v}s_{\bar{x}} = 0.0610$ $^{w}s_{\bar{x}} = .00923$ $^{x}s_{\bar{x}} = 0.0655$ $^{y}s_{\bar{x}} = .00862$ $^{z}s_{\bar{x}} = .00760$

Lowest SS readings were from fruits of clone 157. This clone had guavas with the lowest phosphorus, but differences for P were not large among genotypes.

The moderately preferred clone 168 had fruits with the lowest amounts of N and low levels of K and P. Guavas from selection 180 contained the lowest levels of CA and low amounts of P. All other parameters were generally intermediate for these genotypes.

Among the 14 genotypes, fruits of 'Beaumont' had the largest L and N values, although M, SS, and K were relatively high. 'Beaumont' guavas had low levels of CA and MG. Smallest measurements of W were from fruits of 'Lucknow-49', while M, N, P, CA, and MG were high.

Fruits from _P. guineense_ x _P. guajava_ had the lowest amounts of K and MG. This highly preferred genotype had long fruits with high M and low SS and PRES measurements. 'Burma' guavas were highest in CA and MG with comparatively smaller fruit dimensions. Nitrogen and P were somewhat high in these fruits. Fruit width, firmness and potassium content were highest in guavas of 'Allahabad Safeda'. Among the 14 genotypes, fruits of this clone had somewhat smaller L dimensions, and low SS, M, MG and CA reading. Potassium content and PRES were high in 'Pink Acid' guavas, while N and K were low.

'Patillo', a moderately preferred to preferred genotype, had low levels of N and M in the fruits. All other fruit measurements for this clone were intermediate.

High amounts of K, P and MG were recovered from Ruby x Supreme fruits. These fruits had high measurements for PRES and low quantities of M and CA. 'Hong Kong Pink' guavas had fruits with the highest SS readings.

Genotype differences in fruit preference of the RBT were observed among various local acid-type selections, seven Psidium accessions and an interspecific Psidium cross. Breeding for thrip-resistant guava cultivars could be used as a control measure in lieu of or in conjunction with chemical control measures. The existence of genetic differences in insect resistance has been supported by Callan (1943), Fennah (1951, 1954), Gallun (1972), Lange (1978), Painter (1968), Sakimura (1961) and Waiss (1977). The benefits derived from resistant crops are often subtle or obscure, due to the gradual incorporation of resistance into cultivars (Dahms, 1972). However, Harris and Lamb (1973) observed the transmission of resistance to Pear psylla in F_1 hybrids of P. communis (susceptible) x P. ussuriensis (resistant). Identification, incorporation and stabilization of the resistant gene(s) are three fundamental factors that must be considered in developing resistant plants (Dahms, 1972). Old susceptible varieties should be continually replaced by new cultivars (Gallun, 1972; Dahms, 1972).

Guava fruit preference tests conducted by Cooper (1977) were not in agreement with the findings of this study. Variations in fruit preference over the fruiting season (Fig. 21) suggest that preference tests conducted over a narrow range of fruit growth are subject to bias and possible misleading conclusions. The need for repeated fruit sampling and testing of preference to provide accuracy in conclusions on the genetic variation of resistance have been achieved in this study.

Utilization of an augmented design in the study of thrip resistance in guava was considered useful in identifying possible sources of resistance. This method has the disadvantages of increased complexities in statistical computations, larger coefficients of variation values, and constraints on the number of possible parameters of interest that may be examined using multiple regression techniques when the number of degrees of freedom of the residual error is small.

Mean values of percent nutrient content of P, K, CA and MG in fruits selected in this experiment for the 14 guava genotypes were higher than those obtained by Hiroce et al., (1977) and Brasil Sobr° et al., (1961), while N was comparatively lower (Appendix 1).

Linear regressions for all parameters, except SS and CA, were significantly correlated with PREF on the combined analysis of 14 Psidium genotypes (Table 8). N content was the most highly correlated parameter (r = -0.410) and indicated that it is an important factor associated with RBT preference in guavas (Fig. 22).

Significant correlations between preference and a number of the other variables suggested that preference may be associated with more than one parameter. Multiple regression analyses were performed

TABLE 8. Linear regression equations, coefficients of determination (R^2) and correlation coefficients (r) between preference and ten fruit parameters on the combined analysis of 14 Psidium genotypes.

Comparisons	Equations	R^2	r
TPREF(Y) vs L (X)	Y = 5.81 + 1.96 X	.080	.283***
TPREF(Y) vs W (X)	Y = 2.49 + 2.88 X	.129	.359***
TPREF(Y) vs M (X)	Y = -5.00 + 0.296X	.110	.332***
TPREF(Y) vs PRES(X)	Y = 24.01 - 0.349X	.117	-.342***
TPREF(Y) vs SS (X)	Y = 16.57 - 0.019X	.000	-.005ns
TPREF(Y) vs N (X)	Y = 24.65 - 9.93 X	.168	-.410***
TPREF(Y) vs K (X)	Y = 32.274 - 9.64 X	.105	-.324***
TPREF(Y) vs P (X)	Y = 22.37 - 32.63 X	.083	-.288***
TPREF(Y) vs CA (X)	Y = 14.76 + 17.47 X	.009	.093ns
TPREF(Y) vs MG (X)	Y = 23.34 - 68.46 X	.090	.300***

***Significant at 0.01% level.

ns = nonsignificant at 5% level.

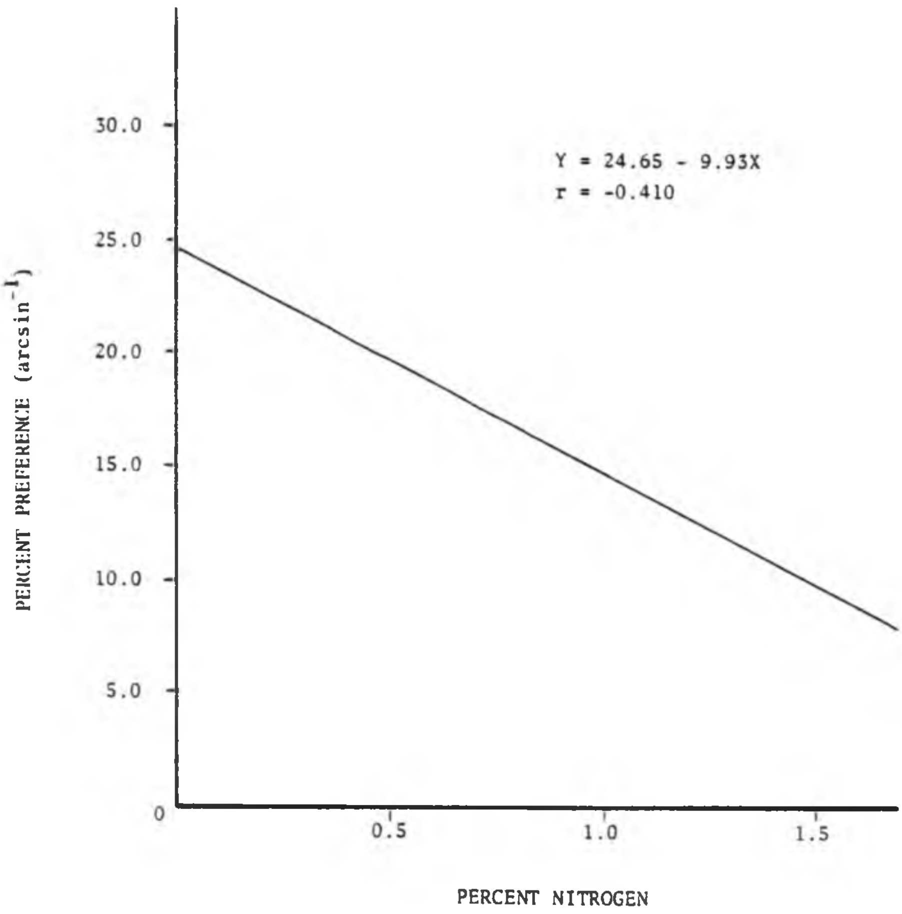

Figure 22. Best regression equation between preference and ten fruit parameters on the combined analysis of 14 *Psidium* genotypes.

using preference (Y) and various fruit parameters (X) to obtain a minimum of unexplained residual variance (Table 9). Sequential F-test and R-squared analyses showed that inclusion of the parameter PRES into the regression model containing N was significant (Table 10). This equation accounted for a greater portion of the variation than entry of either K or M into the regression model with N. Addition of K into the model already containing N and PRES was worthwhile, as indicated by the significant sequential F-test and an increase in the value of the R^2. Entry of additional variables failed to improve the equation significantly. A model containing the variables N, PRES, and K was chosen as the best fit equation associated with preference, which explained a greater proportion of the variation than N alone. Voss _et al_. (1970) suggests using a model containing the maximum amount of information to describe an independent variable (TPREF) with the fewest number of dependent variables, such as N, K and PRES.

Nitrogen, the most highly correlated parameter with RBT-preference in guavas (Table 8), was an important nutrient associated with RBT-attack on cacao (Fennah, 1955, 1965; McDonald, 1932). Ruehle (1948) stresses that nitrogen may be particularly required during the period of fruit sizing, since total N content of guava fruit rapidly decreases during development with a corresponding increase in mean weights and diameters (LeRiche, 1951). Guava cropping twice a year indicated the need to furnish supplemental N (Khera and Chundawat, 1977). Application of ammonium nitrate

TABLE 9. Multiple regression equations and coefficients of determination (R^2) between preference and ten fruit parameters on the combined analysis of 14 *Psidium* genotypes.

Equations	R^2
TPREF = 28.610 - 8.209N - 0.248PRES	.222*
TPREF = 32.140 - 8.057N - 5.492K	.196***
TPREF = 12.189 - 8.029N + 0.151M	.214***
TPREF = 36.012 - 6.366N - 0.246PRES - 5.437K	.245***
TPREF = 29.813 - 6.654N + 0.418PRES - 5.291K - 0.017PRES	.260***
TPREF = 19.628 - 6.598N - 4.675K + 0.138M	.234***
TPREF = 23.491 - 5.124NK	.190***
TPREF = 27.709 - 4.350NK - 0.243PRES	.245***
TPREF = 25.238 - 4.501NK - 0.005PRES^2	.235***

* Significant at 0.1% level.

***Significant at 0.01% level.

TABLE 10. Sequential F-test of regression analysis for the fruit parameters.

Source	df	MS	F
Regression/b_o	3	354.470	17.299***
Partition			
b_1/b_o	1	716.759	35.324***
b_2/b_1, b_o	1	229.247	11.298***
b_3/b_2, b_1, b_o	1	117.406	5.786*
Residual	156	20.291	

b_o, b_1, b_2, b_3 = Regression due to mean, average percent content of N, PRES and K, respectively.

***Significant at 0.1% level.

* Significant at 5% level.

decreased spider mite, *Tetranychus urticae* Koch, densities on strawberries (Poe *et al*., 1976).

Guava fruit firmness, which was another important parameter (Fig. 25), was generally high among the 14 genotypes with measurements ranging between 18.96 and 25.08 lb (Table 6). Strawberry breeders have made significant progress in developing new cultivars with outstanding fruit firmness due to the large additive genetic variance and high heritability associated with fruit firmness. Large differences were observed in the phenotypic assessment of puncture force from the parental strawberry clones (Barritt, 1979).

Fluctuations in these three highly related parameters to preference over five combined dates of sampling for a preferred (157), moderately preferred ('Beaumont') and nonpreferred ('Allahabad Safeda') genotypes and the average from the 14 genotypes are presented in Figs. 23, 24 and 25.

Alternatively, various groups of guavas may be separated from a population, based on common relationships with preference. Three guava groups were created from the original 14 genotypes using stepwise regression and correlation coefficients. Generally, larger amounts of variation were explained by using this technique (Table 11). Graphical representation of these regressions are presented in Figs. 26, 27 and 28. N content remained to be the most highly correlated parameter involving a majority of the genotypes ($r = -0.648$) and is present in Fig. 26. Genotypes belonging to the group relating TPREF and PRES generally had high mean PRES values (Table 6).

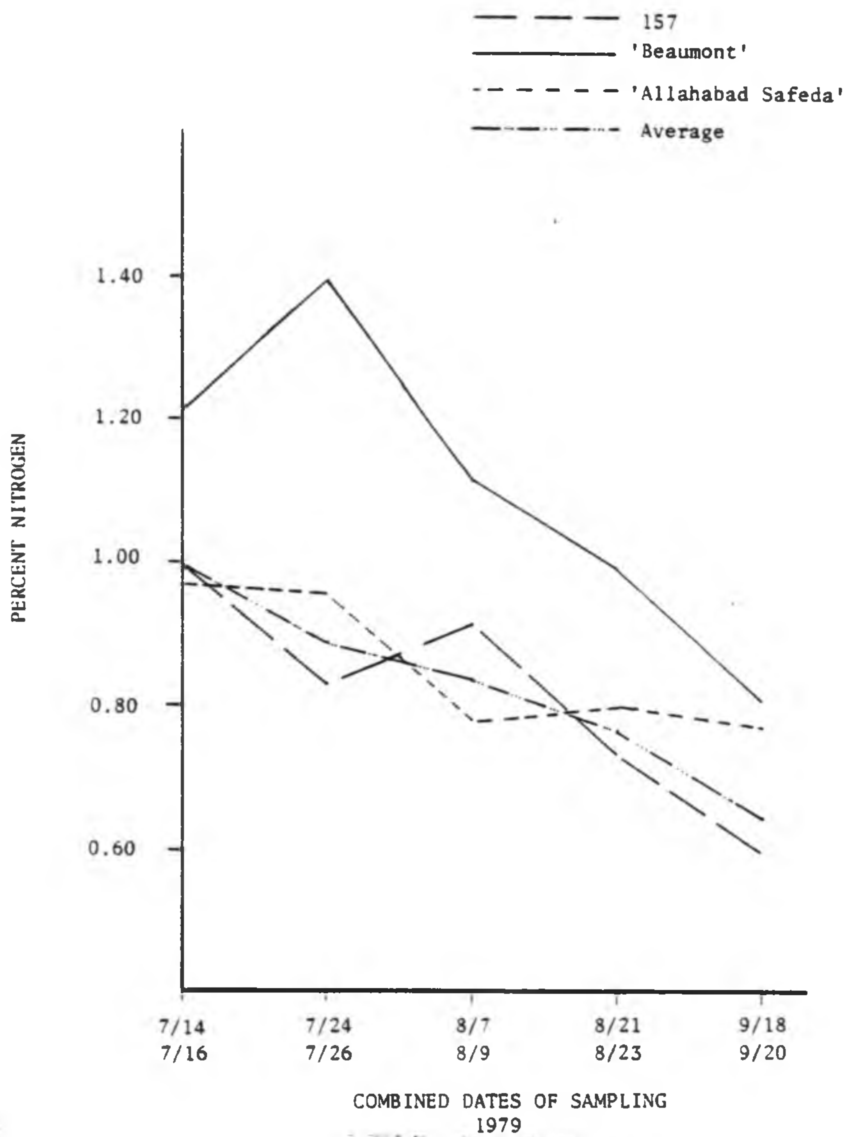

Figure 23. Comparative mean response of percent nitrogen of fruits from three clones and the average over five dates of sampling in 1979.

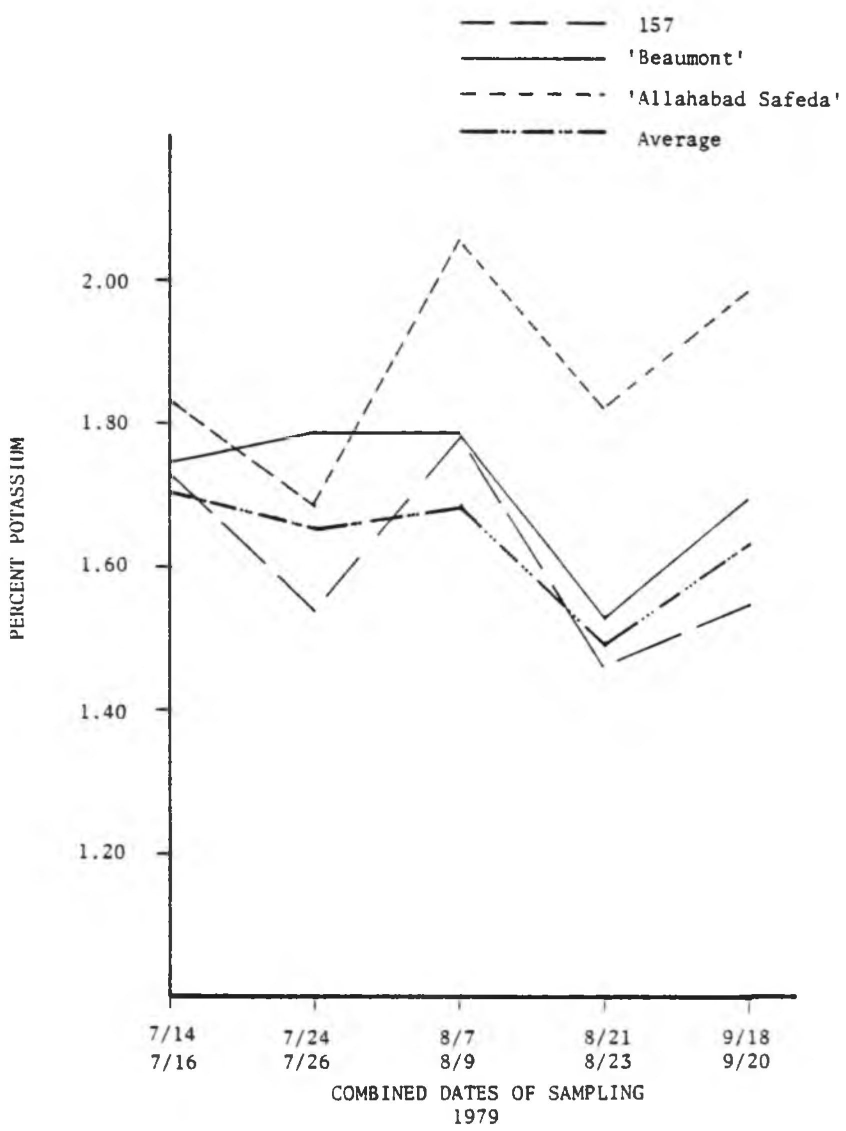

Figure 24. Comparative mean response of percent potassium of fruits from three clones and the average over five dates of sampling in 1979.

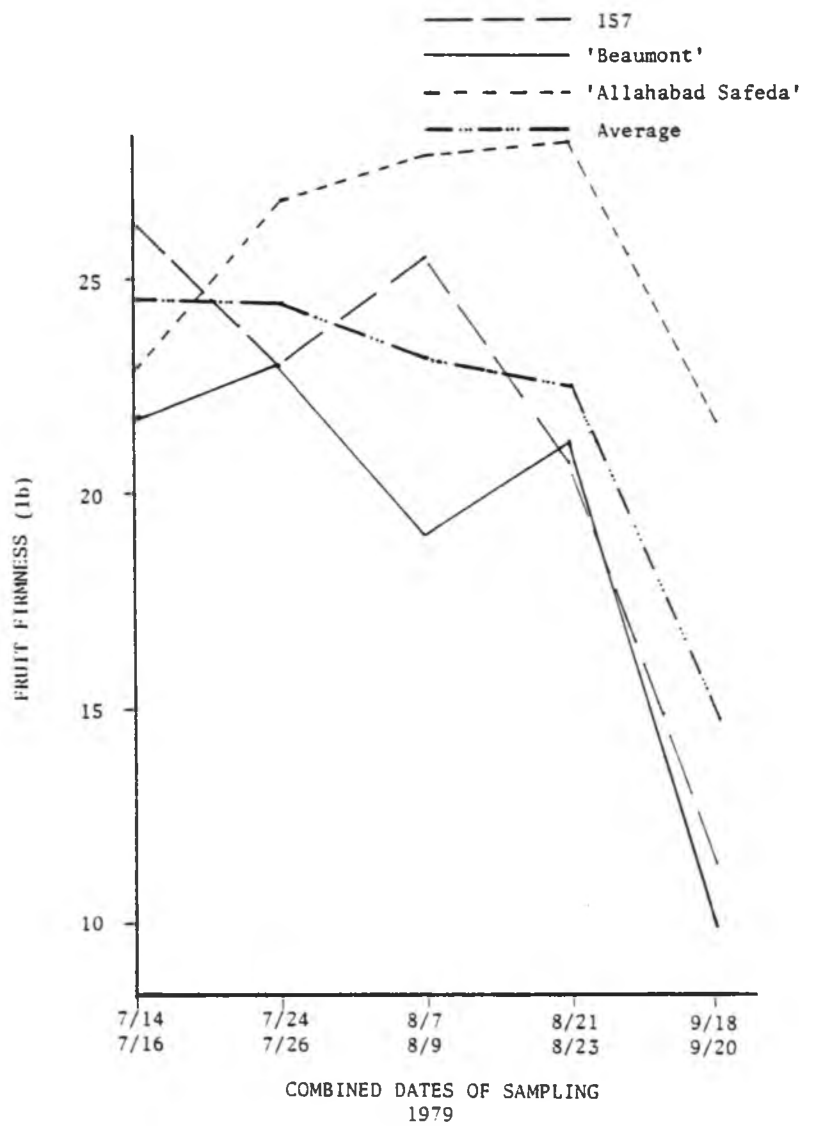

Figure 25. Comparative mean response of fruit firmness from three clones and the average over five combined dates of sampling in 1979.

TABLE 11. Linear regression equations, coefficients of determination (R^2), and correlation coefficients (r) between preference and the best fruit parameter for each of the three *Psidium* groups.

Group	Equation	R^2	r
156 'Beaumont' 'Burma' 'Lucknow-49' *P. guineense* x *P. guajava* 'Patillo'	PREF = 27.544 - 12.544N	.419	-0.648***
143 168 'Allahabad Safeda' Ruby x Supreme 'Hong Kong Pink'	PREF = 29.531 - 0.61PRES	.253	-0.503***
157 180 'Pink Acid'	PREF = 12.257 + 60.429CA	.153	0.391*

* Significant at 0.1% level.
***Significant at 0.01% level.

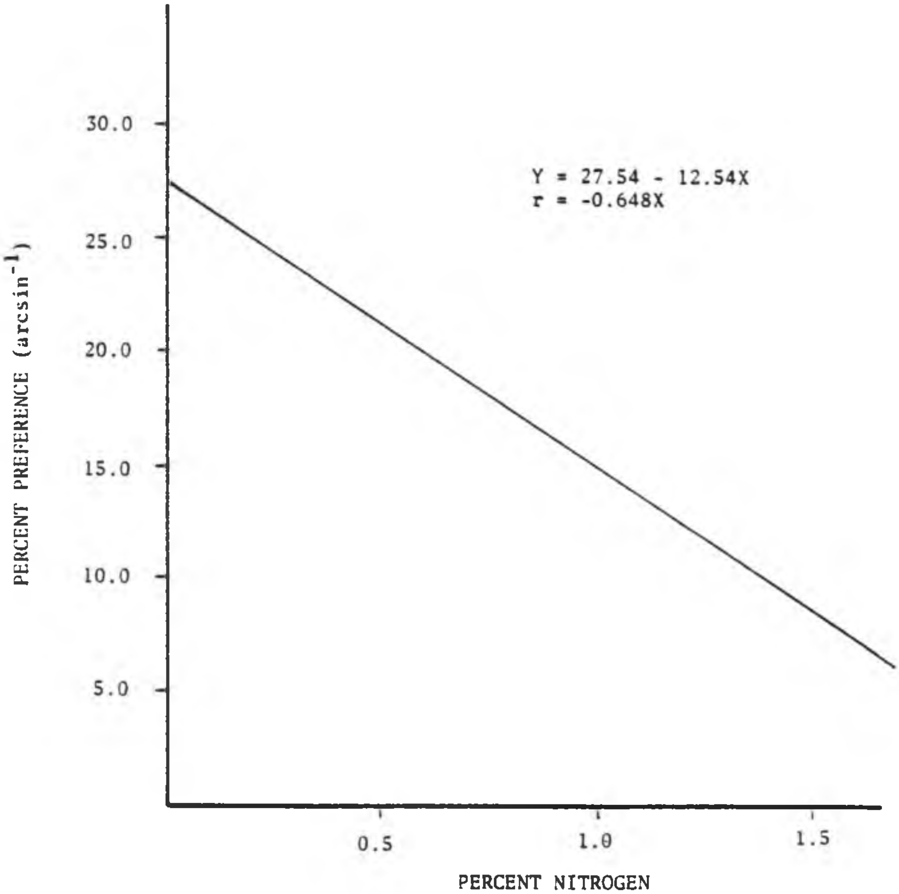

Figure 26. Regression of preference on percent nitrogen of the *Psidium* genotypic group containing 156, 'Beaumont', 'Burma', 'Lucknow-49', *P. guineense* x *P. guajava* and 'Patillo'.

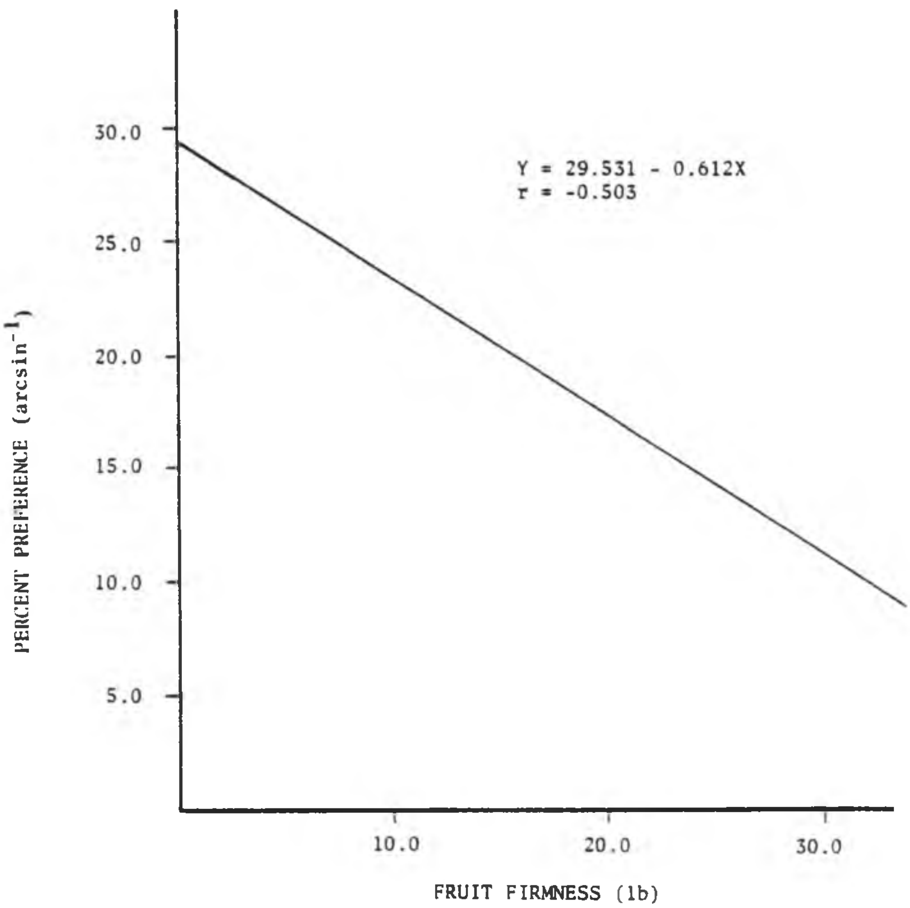

Figure 27. Regression of preference on fruit firmness of the Psidium genotypic group containing 143, 168, 'Allahabad Safeda', Ruby x Supreme, and 'Hong Kong Pink'.

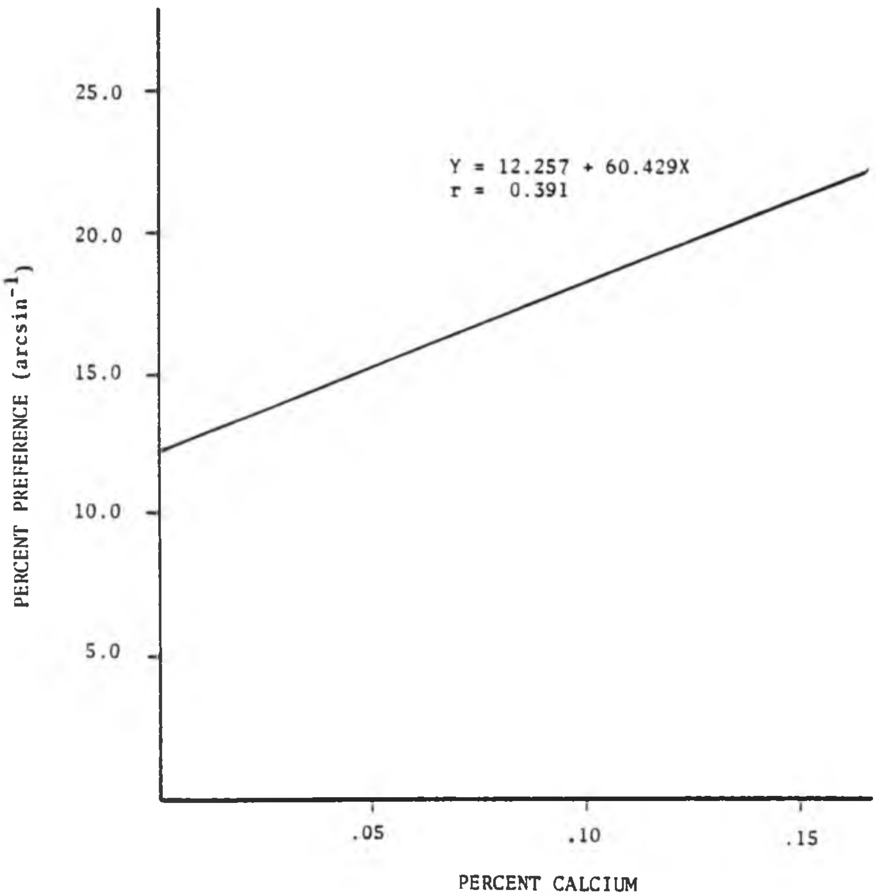

Figure 28. Regression of preference on percent calcium of the <u>Psidium</u> genotypic group containing 157, 180 and 'Pink Acid'.

INFLUENCE OF K FERTILIZATION ON RBT PREFERENCE FOR 143, 157, 180 AND 'BEAUMONT' AND THE RELATIONSHIP OF FRUIT PARAMETERS TO PREFERENCE

Significant differences were not observed between clones for PREF and RATE (Table 12). Preference ratings (RATE) were greater at the high K level, while the differences between the two levels were found to be nonsignificant for PREF (Table 13). Fruits from all the clones and two levels were moderately preferred. Mean separation was not large between the interacting effects of clones and K level for PREF and RATE (Table 14).

Data on the fruit parameters measured in this experiment for the four clones treated with two K levels are summarized in Tables 15-18. Small significant differences were observed in the fruit dimensions of L and W between the four clones. Moisture content was greatest in 'Beaumont' and least in clones 143 and 180. Fruits from clone 180 had the largest measurements for fruit firmness. Highest total soluble solids readings were from fruits of clone 143 and lowest from 157 and 'Beaumont'. Percent nutrient content of N, P and K was lowest in clone 157. 'Beaumont' fruits contained high amounts of N, while K content was highest from clone 180.

Variations in the selected parameters, except SS, were not significant between fruits harvested from the two K levels (Tables 16 and 18).

Parameter values for fruits selected in this experiment between September 25 and October 18, 1979 were compared with those selected in earlier studies between July 17 and September 20 (Table 19).

TABLE 12. Comparison of % RBT response (PREF) and insect rating (RATE) for fruits from four clones sampled over seven dates.*

Clone	PREF (%)	RATE[y]
143	9.8[ns]	3.4[ns]
157	9.3	3.3
180	10.9	3.6
'Beaumont'	9.5	3.3

[ns]No significant difference at 5% level.

[y]Rating scale measured from 1 = highly nonpreferred, to 5 = highly preferred.

TABLE 13. Comparison of % RBT response (PREF) and insect rating (RATE) for guava fruits sampled over seven dates from trees treated at two K levels.*

K level (g/tree)	PREF (%)	RATE[y]
0	9.3[ns]	3.2 b
1350	10.4	3.6a

*Means with the same letter are not significantly different, 5% level.

[ns]No significant difference at 5% level.

[y]Rating scale measured from 1 = highly nonpreferred, to 5 = highly preferred.

TABLE 14. Comparison of % RBT response (PREF) and insect rating (RATE) for four guava clones grown at two K levels in the field.*

Treatment Clone	K level (g/tree)	PREF (%)	RATE[y]
143	0	8.7ab	3.1ab
	1350	10.9ab	3.8a
157	0	9.1ab	3.2ab
	1350	9.6ab	3.4ab
180	0	11.6a	3.8a
	1350	10.1ab	3.5ab
'Beaumont'	0	8.0 b	2.9 b
	1350	11.1ab	3.8a

*Means with the same letter are not significantly different, 5% level.

[y]Rating scale measured from 1 = highly nonpreferred, to 5 = highly preferred.

TABLE 15. Length (L), width (W), moisture content (M), soluble solids (SS) and firmness (PRES) of fruits sampled on seven dates from four guava clones.*

Clone	L (cm)	W (cm)	M (%)	SS (%)	PRES (lb)
143	6.61a	5.89 b	79.16 c	9.95a	13.58 b
157	6.13 b	6.05a	80.43 b	8.27 c	12.90 b
180	6.52a	5.97ab	78.62 c	8.90 b	16.42a
'Beaumont'	6.67a	5.86 b	81.93a	8.20 c	10.86 c

*Means with the same letter are not significantly different, 5% level.

TABLE 16. Length (L), width (W), moisture content (M), soluble solids (SS) and firmness (PRES) of fruits sampled on seven dates from guava trees treated with two K levels.*

K level (g/tree)	L (cm)	W (cm)	M (%)	SS (%)	PRES (lb)
0	6.42a	5.91a	79.79a	9.03a	13.92a
1350	6.55a	5.98a	86.28a	8.62 b	12.96a

*Means with the same letter are not significantly different, 5% level.

TABLE 17. Percent nutrient content of nitrogen (N), phosphorus (P), potassium (K), calcium (CA) and magnesium (MG) of fruits sampled on seven dates from four guava clones.*

Clone	Percent Nutrient Content				
	N	P	K	CA	MG
143	0.728 b	0.167a	1.618 b	0.116a	0.101a
157	0.642 c	0.133 c	1.461 c	0.126a	0.091 b
180	0.809a	0.148 b	1.699a	0.070 c	0.100a
'Beaumont'	0.844a	0.143 b	1.495 c	0.091 b	0.087 b

*Means with the same letter are not significantly different, 5% level.

TABLE 18. Percent nutrient content of nitrogen (N), phosphorus (P), potassium (K), calcium (CA) and magnesium (MG) of fruits sampled on seven dates from guava trees treated with two K levels.*

K level (g/tree)	Percent Nutrient Content				
	N	P	K	CA	MG
0	0.764a	0.147a	1.562a	0.097a	0.093a
1350	0.748a	0.148a	1.575a	0.104a	0.096a

*Means with the same letter are not significantly different, 5% level.

TABLE 19. Changes in the mean parameter values for guava fruits sampled during two periods in 1979.

Parameters	PERIOD (1979)		d*
	7/17-9/20	9/25-10/18	
L	5.29	6.48	+1.19
W	4.76	5.94	+1.18
M	71.80	80.04	+8.24
SS	9.05	13.34	+4.39
PRES	22.20	8.83	-13.37
N	.828	.756	-.072
K	1.661	1.568	-.093
P	.185	.148	-.037
CA	.096	.101	+.005
MG	.105	.095	-.010

*d = Difference between values from the two periods.

Increases were observed for L, W, M, SS and CA, while values for PRES, N, K, P and MG decreased. Hence, fruits selected for these tests were on the average more mature than those selected earlier, as expected. This may have caused the inability for differences in % insect response to occur.

Preference measured over sampling dates in this experiment was not related to the ten fruit parameters in a linear manner (Table 20). A low R^2 value for the equation relating fruit width and preference negated the use of this equation, which was significant.

Guava leaf analyses showed significant fluctuation in N and K content over nine sampling dates (Table 21). Potassium content in leaf tissue generally increased in all clones following treatment with potassium (Fig. 29), while decreasing levels of N were observed over sampling dates (Fig. 30).

Highest amounts of N were observed in foliar tissue of 'Beaumont' (Table 22). Leaves of clone 180 contained significantly more K, followed by 'Beaumont', 143 and 157 over the nine sampling dates.

Small differences in K content were observed between K levels (Table 23) while no significant variations were observed for nitrogen. Foliar K was lowest in samples taken from all unfertilized clones (Table 24). Lowest levels of K were recovered in clone 157 fertilized with no potassium and greatest in leaves taken from clone 180 grown at the highest K level. Nitrogen was generally highest in leaves from trees fertilized with K for all

TABLE 20. Linear regression equations and coefficients of determination (R^2) between preference and ten fruit parameters for four guava clones treated with two K levels.

Comparison	Equation	R^2
TPREF(Y) vs L (X)	Y = 20.726 - 0.361X	.002
TPREF(Y) vs W (X)	Y = 4.675 + 2.324X	.044*
TPREF(Y) vs M (X)	Y = 13.316 + 0.064X	.003
TPREF(Y) vs PRES(X)	Y = 19.221 - 0.056X	.012
TPREF(Y) vs SS (X)	Y = 19.902 - 0.166X	.005
TPREF(Y) vs N (X)	Y = 22.333 - 5.211X	.030
TPREF(Y) vs K (X)	Y = 16.032 + 1.507X	.006
TPREF(Y) vs P (X)	Y = 20.683 - 15.485X	.006
TPREF(Y) vs CA (X)	Y = 17.963 + 4.286X	.001
TPREF(Y) vs MG (X)	Y = 16.610 + 18.874X	.004

*Significant at 5% level.

TABLE 21. Comparison of nitrogen (N) and potassium (K) content in leaf tissue taken from four guava clones treated with two K levels on nine dates.*

Month	Year	Percent nutrient content	
		N	K
June	1978	1.505 b	1.480 f
July	1978	1.386 c	2.054a
August	1978	0.779 e	1.896 b
February	1979	1.555ab	1.085 g
April	1979	1.618a	1.846 bc
June	1979	1.512 b	1.599 e
August	1979	1.342 c	1.715 d
October	1979	1.211 d	1.400 f
December	1979	1.170 d	1.767 cd

*Means with the same letter are not significantly different, 5% level.

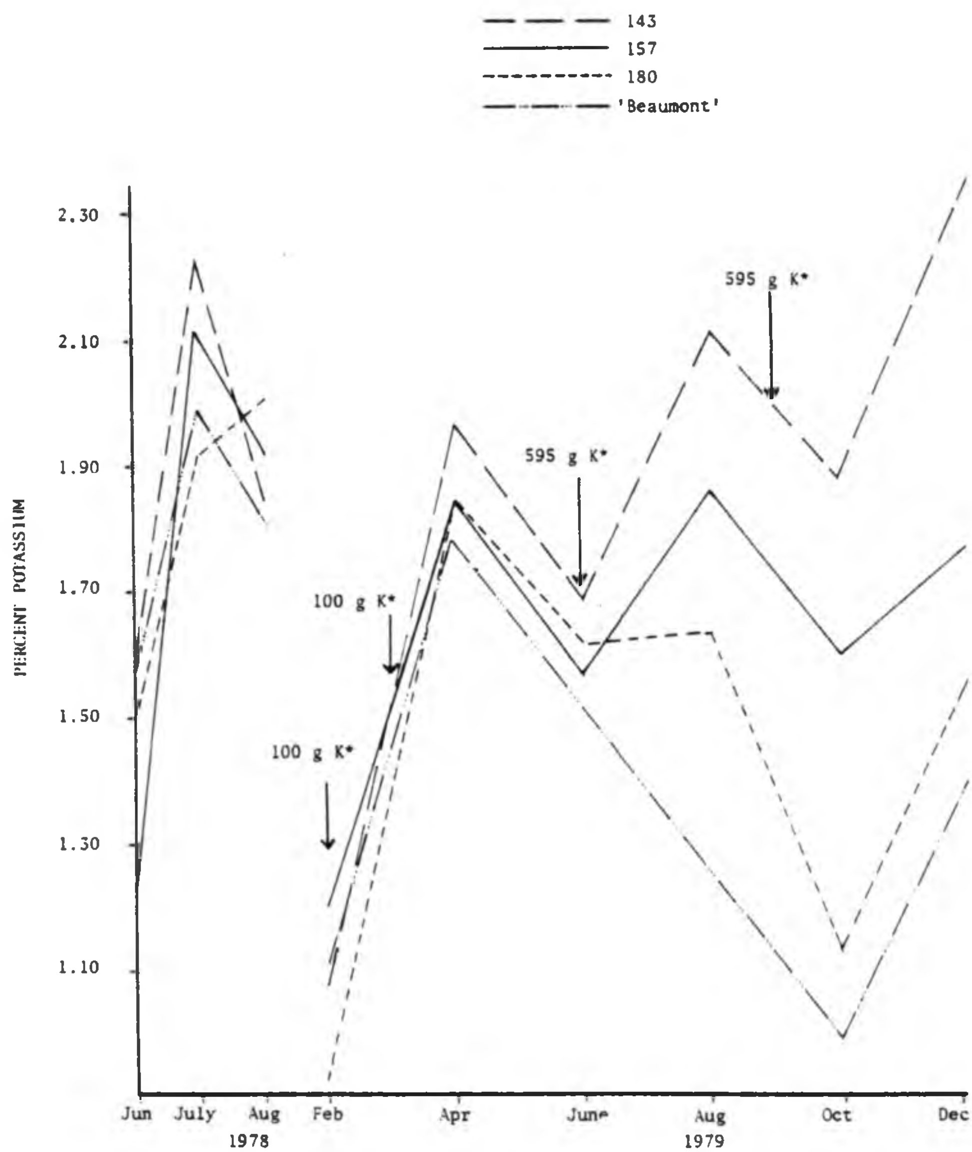

Figure 29. Monitoring of potassium concentrations in guava leaves in 1978 and 1979.

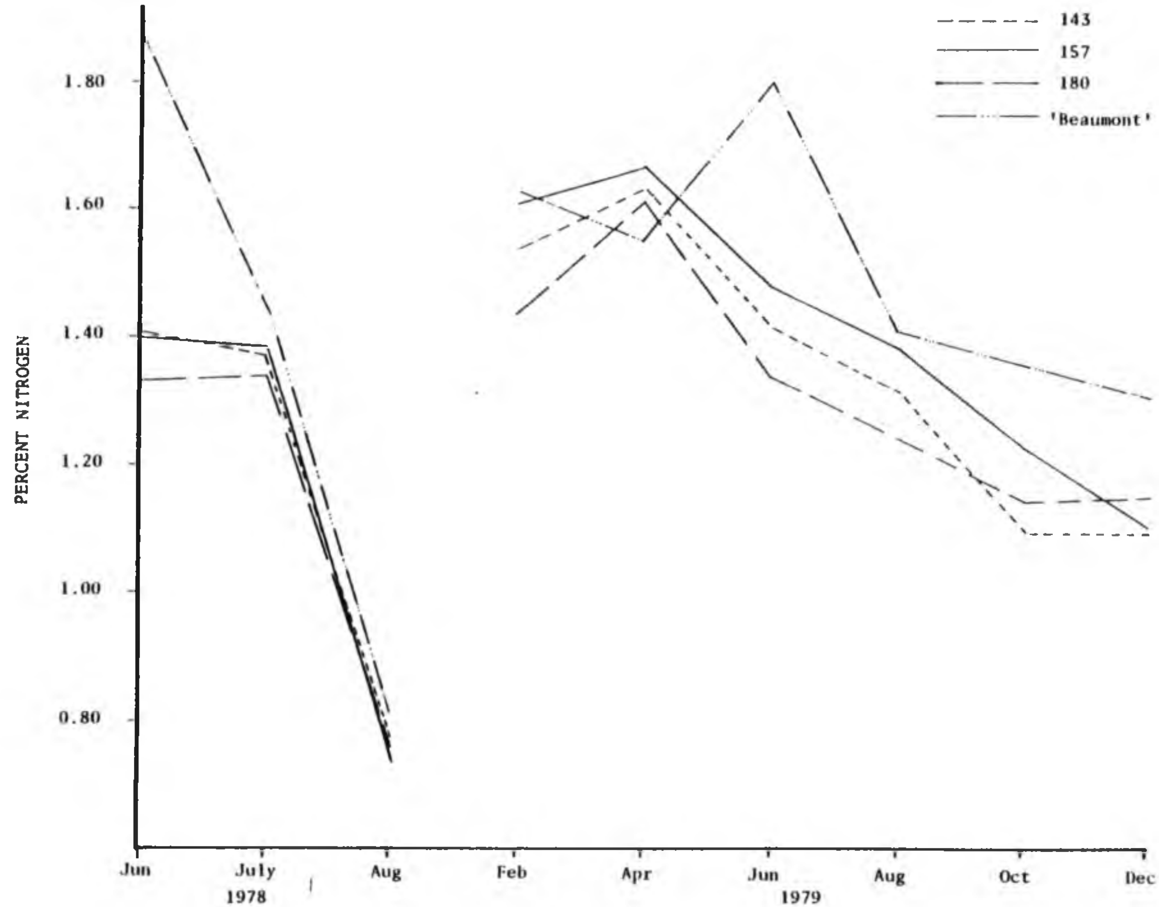

Figure 30. Monitoring of nitrogen concentrations in guava leaves in 1978 and 1979.

TABLE 22. Percent nutrient content of nitrogen (N) and potassium (K) in leaves from four guava clones taken on nine dates of sampling.*

Clone	Percent nutrient content	
	N	K
143	1.297 bc	1.567 c
157	1.337 b	1.491 d
180	1.264 c	1.859a
'Beaumont'	1.468a	1.680 b

*Means with the same letter are not significantly different, 5% level.

TABLE 23. Percent nutrient content of nitrogen (N) and potassium (K) in leaves from two K levels taken on nine dates of sampling.*

K level (g/tree)	Percent nutrient content	
	N	K
0	1.330a	1.618 b
1350	1.353a	1.681a

*Means with the same letter are not significantly different, 5% level.

TABLE 24. Interacting effects of four guava clones and two K levels over nine dates of sampling for percent nutrient content of nitrogen (N) and potassium (K) in leaves.*

Treatment Clone	K level (g/tree)	Percent nutrient content N	K
143	0	1.278 bc	1.537 ef
	1350	1.317 b	1.597 de
157	0	1.350 b	1.482 f
	1350	1.324 b	1.500 f
180	0	1.227 c	1.788 b
	1350	1.302 b	1.930a
'Beaumont'	0	1.467a	1.663 cd
	1350	1.470a	1.697 c

*Means with the same letter are not significantly different, 5% level.

of the clones, except 157.

The results of this experiment indicated that there was a small response in K content to application of 1350 g K per tree.

EFFECT OF K LEVELS ON CLONES 157, 180 AND 'BEAUMONT' GROWN IN CONTAINERS AND THE RELATIONSHIP OF FRUIT PARAMETERS TO PREFERENCE

Lowest percent preference or ratings was observed in fruits from clone 180 and highest in clone 157 (Table 25). Fruits from 'Beaumont' were rated intermediate in preference with a rating of 2.9. Increasing levels of K fertilization was associated with decreases in preference (Table 26).

Percent RBT response to three guava clones was significantly different among K levels (Table 27). Guava fruit preference by RBT was significantly lower at the highest K level for 'Beaumont'. Insect ratings for 'Beaumont' fruits decreased from 3.6 to 1.9 at the 0 and 9 g K level, respectively. Fruits from 'Beaumont' and 180 at the 9 g K level were the least preferred and those from 157 and 'Beaumont' treated at 0 g K were high in preference.

Summarized in Tables 28-31 are the means of the fruit parameters measured in this experiment for 'Beaumont', 157 and 180 treated at three potassium levels.

Fruits of clone 157 had the largest measurements of L, W and CA content, while fruit size and content of calcium was not different between 180 and 'Beaumont' (Tables 28 and 30). N content of 'Beaumont' was highest and lowest in 157. Clone 180 had the highest P and K content. Differences in M, PRES and SS were not

TABLE 25. Comparison of % RBT response (PREF) and insect rating (RATE) for fruits from three guava clones grown in containers.*

Clone	PREF (%)	RATE[y]
'Beaumont'	8.7a	2.9ab
157	9.9a	3.5a
180	5.5 b	2.5 b

*Means with the same letter are not significantly different, 5% level.

[y]Rating scale measured from 1 = highly nonpreferred, to 5 = highly preferred.

TABLE 26. Comparison of % RBT response (PREF) and insect rating (RATE) for guava fruits from plants grown at three K levels.*

K level (g K/pot)	PREF (%)	RATE[y]
0	10.5a	3.2a
3	8.0ab	3.1a
9	5.5 b	2.5a

*Means with the same letter are not significantly different, 5% level.

[y]Rating scale measured from 1 = highly nonpreferred, to 5 = highly preferred.

TABLE 27. Comparison of % RBT response (PREF) and insect rating (RATE) for fruits from three guava clones grown at three K levels in containers.*

Treatment		PREF	RATE[y]
Clone	K level	(%)	
Beaumont	0	15.9a	3.6a
	3	9.0abc	3.3ab
	9	3.4 d	1.9 b
157	0	11.6ab	3.6a
	3	7.6 bcd	3.1ab
	9	10.5ab	3.6a
180	0	5.3 bcd	2.4ab
	3	7.5 bcd	2.9ab
	9	3.9 cd	2.1ab

*Means with the same letter are not significantly different, 5% level.

[y]Rating scale measured from 1 = highly nonpreferred, to 5 = highly preferred.

TABLE 28. Length (L), width (W), moisture content (M), soluble solids (SS) and firmness (PRES) of fruits from three guava clones grown in containers.*

Clone	L (cm)	W (cm)	M (%)	SS (%)	PRES (lb)
'Beaumont'	5.2 b	4.4 b	78.3a	7.18a	17.83a
157	5.6a	5.0a	78.5a	6.80a	17.30a
180	5.1 b	4.4 b	77.5a	7.19a	18.47a

*Means with the same letter are not significantly different, 5% level.

TABLE 29. Length (L), width (W), moisture content (M), soluble solids (SS) and firmness (PRES) of fruits from guava plants grown at three K levels.*

K level (g/pot)	L (cm)	W (cm)	M (%)	SS (%)	PRES (lb)
0	5.5a	4.8a	78.9a	7.04a	15.7a
3	5.3ab	4.7ab	77.5a	7.29a	19.0a
9	5.1 b	4.4 b	77.9a	6.84a	18.9a

*Means with the same letter are not significantly different, 5% level.

TABLE 30. Percent nutrient content of nitrogen (N), phosphorus (P), potassium (K), calcium (CA) and magnesium (MG) of guava fruits sampled from four guava clones grown in containers.*

Clone	Percent Nutrient Content				
	N	P	K	CA	MG
'Beaumont'	1.112a	0.192 b	2.320a	0.119ab	0.105ab
157	0.858 c	0.186 b	2.047 b	0.136a	0.101 b
180	0.988 b	0.206a	2.349a	0.107 b	0.109a

*Means with the same letter are not significantly different, 5% level.

TABLE 31. Percent nutrient content of nitrogen (N), phosphorus (P), potassium (K), calcium (CA) and magnesium (MG) of fruits sampled from guava plants grown at three K levels.*

K level (g/pot)	Percent Nutrient Content				
	N	P	K	CA	MG
0	1.016a	0.195a	2.120 b	0.113a	0.103a
3	0.947a	0.193a	2.196 b	0.121a	0.104a
9	0.995a	0.195a	2.400a	0.127a	0.109a

*Means with the same letter are not significantly different, 5% level.

significant among clones.

L and W were largest in the fruits taken from plants treated at the two lowest K levels. Significant differences in M, PRES, SS, N, P, CA and MG were not found between the three K levels (Tables 29 and 31). Fruits from the high potassium level had the highest K content, as expected.

The results from this experiment indicate that there is a genotypic difference in fruit preference (Table 25) and that K fertilization contributes to increased resistance to that already expressed by a particular clone (Table 27).

Interactions of clones with K level on L, W, M, PRES, SS, N, P, K, CA and MG are summarized in Tables 32 and 33. Significant differences were found among all of the parameters.

Length and width of fruits selected for these tests were generally smallest at the highest K level (Table 32). Fruits from clone 157 at the lowest fertilizer level had the greatest length and width measurements. The smallest measurements of L and W were observed in fruits from 'Beaumont' at the high K level, which were the least preferred. Fruits from 'Beaumont' at the 0 K level had the lowest PRES readings, and highest M. Conversely, 'Beaumont' fruits had the highest measurements of firmness and low M at the highest K level.

Increasing K fertilization was associated with greater content of K in guava fruits for all three clones, as expected. Fruits from the highest rate of K fertilization for clone 180 contained

TABLE 32. Length (L), width (W), moisture content (M), soluble solids (SS) and firmness (PRES) of fruits sampled from three guava clones grown at three K levels in containers.*

Treatment Clone	K level (g/pot)	L (cm)	W (cm)	M (%)	SS (%)	PRES (lb)
'Beaumont'	0	5.5ab	4.8abcd	82.6a	6.2 c	10.3 c
	3	5.3abcd	4.5 bcde	76.6 bc	7.8a	21.2 ab
	9	4.8 d	4.0 e	75.6 bc	7.6ab	22.0a
157	0	5.8a	5.2a	79.7ab	7.1abc	15.3 bc
	3	5.4abc	4.9abc	77.3 bc	6.9abc	18.7ab
	9	5.5ab	5.1ab	78.6 b	6.4 c	17.9ab
180	0	5.2 bcd	4.4 cde	74.3 c	7.8a	21.5ab
	3	5.3abcd	4.7abcd	78.6 b	7.2abc	17.3ab
	9	4.9 cd	4.2 de	79.6ab	6.6 bc	16.6ab

*Means with the same letter are not significantly different, 5% level.

the greatest MG with the lowest PREF and measurements of L and W. Trends in the interactions of clones and K levels for N, P and CA were not clear. Percent nutrient content of N, P, K and MG in guava fruit were lowest in clone 157 at the lowest K fertilizer level (Table 33). Low amounts of CA were also observed in these preferred fruits. Fruits of clone 180 contained the least amount of CA at 0 g of K.

These results suggest that RBT preference was least in guava fruits with low measurements of L, W and M and high measurements of PRES, K and MG. Highest preference was observed in longer, wider and softer fruits with low N, P, K, MG and CA.

The significant relationship (P less than .05%) between K levels and percent preference for three guava clones indicate that the management practice of K fertilization may be a significant factor in guava fruit preference by RBT (Fig. 31). Other variables besides K level are probably affecting preference, since the values of the correlation coefficient (r = -0.376) and the coefficient of determination (R^2 = .141) were low. This level of accuracy could not be improved using a nonlinear model that included a second degree polynomial relating K level to preference.

Regression equations and correlation coefficients between preference and fruit characters are presented in Table 34. Correlation analyses involving RBT preference and percent K, MG and M and L, W and PRES values were highly significant.

TABLE 33. Percent nutrient content of nitrogen (N), phosphorus (P), potassium (K), calcium (CA) and magnesium (MG) of fruits from three guava clones grown at three K levels in containers.*

Treatment		Percent Nutrient Content				
Clone	K level	N	P	K	CA	MG
'Beaumont'	0	1.232a	0.200ab	2.185 bc	0.134ab	0.105ab
	3	0.988 bc	0.185 bc	2.233 bc	0.098 bc	0.101ab
	9	1.115ab	0.190 bc	2.543a	0.124abc	0.110ab
157	0	0.758 d	0.171 c	1.828 d	0.117 bc	0.097 b
	3	0.883 cd	0.195ab	2.105 c	0.156a	0.103ab
	9	0.935 bcd	0.191 bc	2.208 bc	0.135ab	0.103ab
180	0	1.058abc	0.215a	2.348abc	0.088 c	0.107ab
	3	0.970 bc	0.199ab	2.250 bc	0.111 bc	0.107ab
	9	0.935 bcd	0.203ab	2.450ab	0.123abc	0.113a

*Means with the same letter are not significantly different, 5% level.

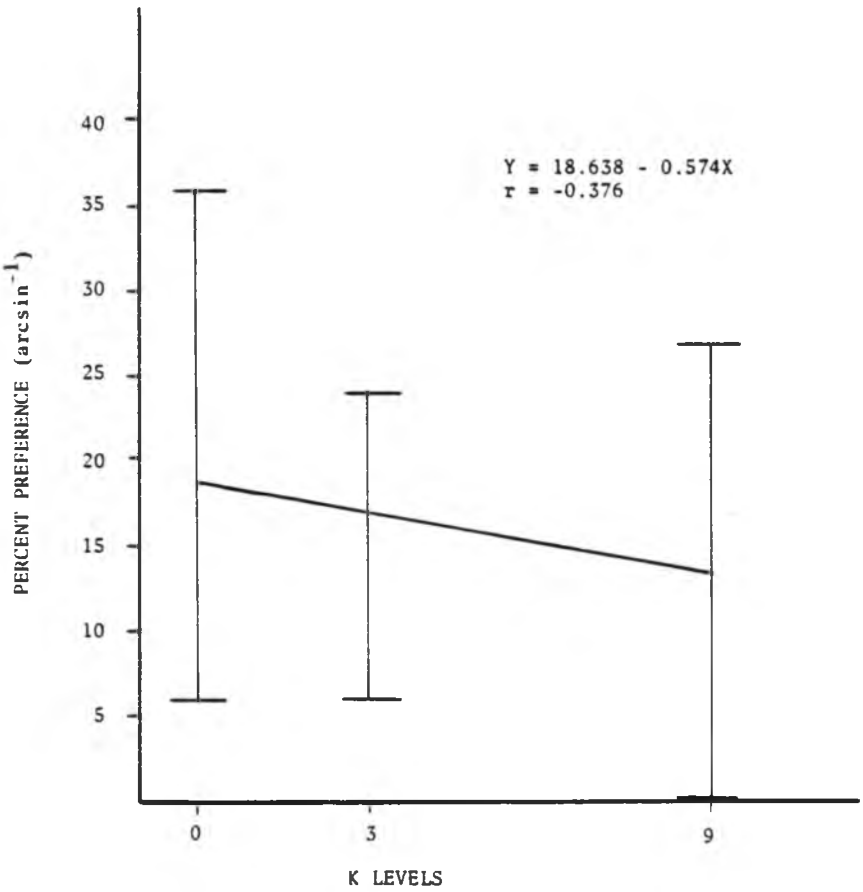

Figure 31. Regression of preference on K levels for three guava clones grown in containers (vertical lines indicate range).

TABLE 34. Linear regression equations, coefficients of determination (R^2), and correlation coefficients (r) between PREF and ten fruit parameters on the combined analysis of three guava clones.

Comparison	Equation	R^2	r
TPREF(Y) vs L (X)	Y = -18.960 + 6.63 X	.271	.520**
TPREF(Y) vs W (X)	Y = -14.065 + 6.53 X	.315	.561**
TPREF(Y) vs M (X)	Y = -54.631 + 0.908X	.241	.491**
TPREF(Y) vs PRES(X)	Y = 27.886 - 0.642X	.320	-.566**
TPREF(Y) vs SS (X)	Y = 31.506 - 2.143X	.091	-.301
TPREF(Y) vs N (X)	Y = 20.210 - 3.921X	.014	-.119
TPREF(Y) vs P (X)	Y = 37.623 - 109.515X	.117	-.342*
TPREF(Y) vs K (X)	Y = 39.882 - 10.515X	.218	-.467**
TPREF(Y) vs CA (X)	Y = 19.735 - 28.155X	.019	-.138
TPREF(Y) vs MG (X)	Y = 44.886 - 271.470X	.210	-.459**

**Significant at 1% level.

* Significant at 5% level.

Graphical representation of preference plotted against PRES, K and W are presented in Figs. 32-34. Decreasing trends in preference were observed with increases in fruit firmness (PRES) or potassium (K). Fruit width was the second most highly correlated parameter with preference in this experiment (Fig. 34). An increasing trend was observed between preference and width of guava fruits.

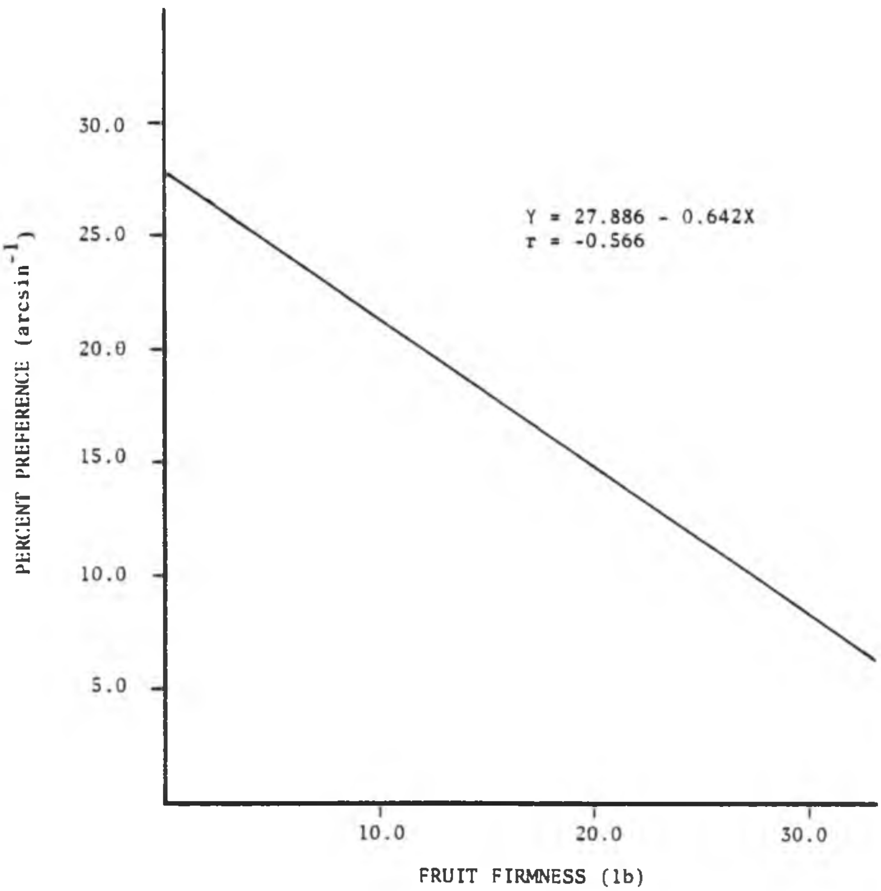

Figure 32. Regression of preference on fruit firmness for three guava clones grown in containers.

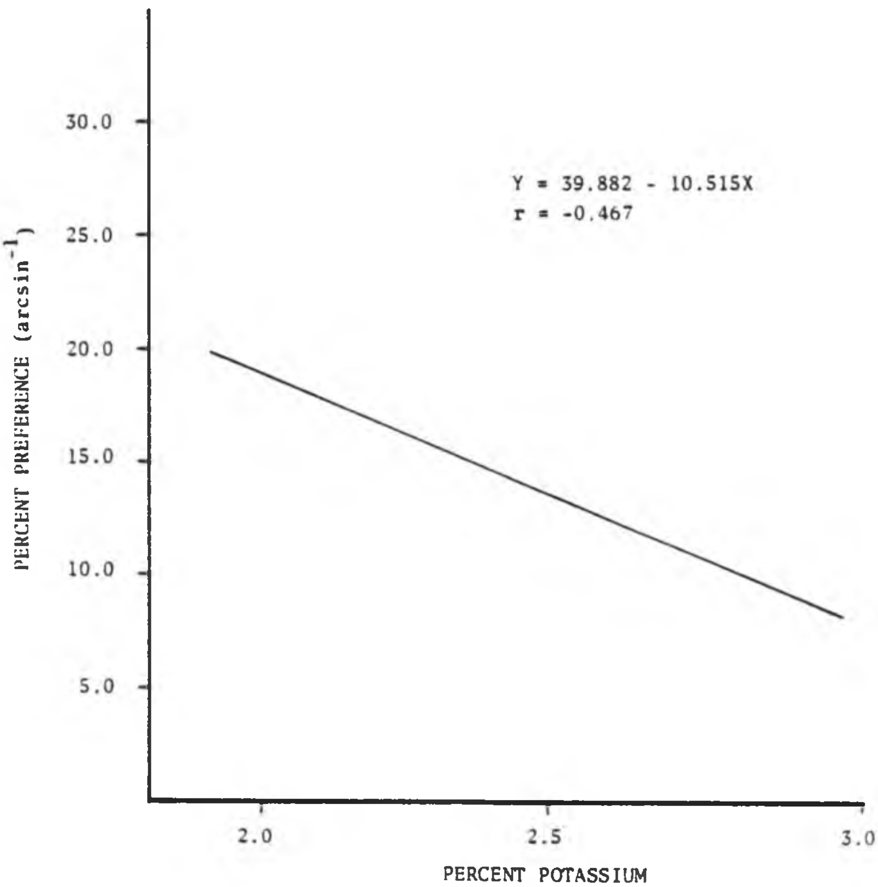

Figure 33. Regression of preference on percent potassium for three guava clones grown in containers.

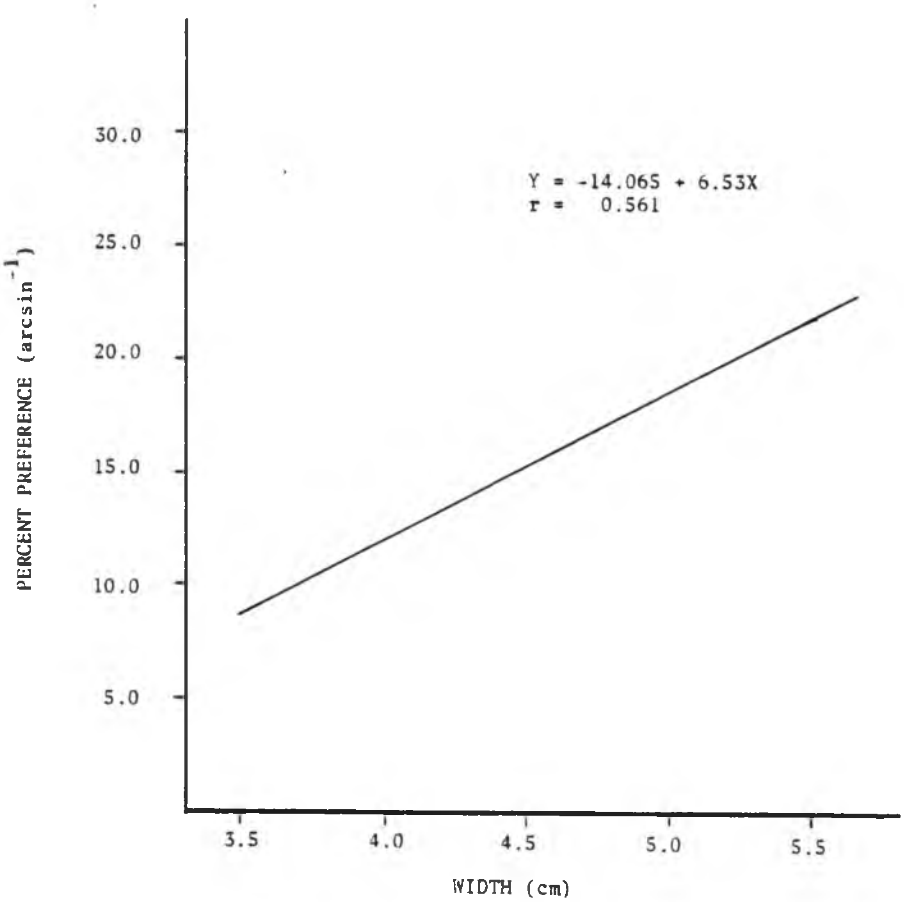

Figure 34. Regression of preference on fruit width for three guava clones grown in containers.

SUMMARY AND CONCLUSIONS

A. COMPARISONS OF RUSSETED AND UNDAMAGED FRUITS

1. Comparatively higher percent soluble solids and total titratable acidity were obtained for puree from russeted fruits than undamaged fruits. Noticeable differences were not observed in the pH of the puree.
2. Large, globular and uncompressed hypodermal cells were characteristic of normal fruits. Epidermal and secretory cells lacked disruptions or irregularities.
3. Russeted fruits showed disruptions in the epidermis. A distinct hypodermal region was lacking and periderm development was evident. Layers of phellogen, phellem and phelloderm were not separable. Lacunae and cracks were observed in the outer cortex where some cells exhibited compression.

B. EVALUATION OF PREFERENCE AMONG VARIOUS *PSIDIUM* GENOTYPES AND THE RELATIONSHIP OF FRUIT PARAMETERS TO PREFERENCE

1. Fruits of 'Beaumont' and possibly clone 180 were least preferred among the six replicated genotypes, indicating the presence of some genetic variation in resistance.
2. Fruits of 'Allahabad Safeda', Ruby x Supreme and 'Lucknow-49' were less preferred than *P. guineense* x *P. guajava* and 'Patillo' and clones 143, 156, 157 and 168.

3. Fruits of 'Burma', 'Hong Kong Pink' and 'Pink Acid' were intermediate in preference.
4. All fruit parameters, except SS and CA were correlated with TPREF in the overall linear regressions of the 14 genotypes.
5. N content was the single most highly correlated parameter with TPREF. High N content was associated with increased resistance.
6. The best multiple regression equation associated with preference was: TPREF = 36.012 - 6.366N - 0.246PRES - 5.437K.
7. Larger amounts of variation between TPREF and the various fruit parameters were explained by grouping guava clones.

C. INFLUENCE OF K FERTILIZATION ON RBT PREFERENCE FOR CLONES 143, 157, 180 AND 'BEAUMONT' AND THE RELATIONSHIP OF FRUIT PARAMETERS TO PREFERENCE

1. Clones selected in these tests were moderately preferred to preferred.
2. No significant differences in preference were observed between the two K levels or between the four clones.
3. Although interactions between clones and K level were significant, mean separation was not large for PREF and RATE.
4. Fruits were more mature than in the earlier study and this may have caused the inability for preference to occur.

5. Leaf analyses showed that N content generally decreased over sampling dates, while significant responses were observed in foliar K content to application of K fertilizer.

D. INFLUENCE OF K FERTILIZATION ON RBT PREFERENCE FOR CLONES 157, 180 AND 'BEAUMONT' GROWN IN CONTAINERS AND THE RELATIONSHIP OF FRUIT PARAMETERS TO PREFERENCE

1. Highest preference was observed for fruits from clone 157 and lowest for clone 180.
2. Fruits from 'Beaumont' were intermediate in preference.
3. Lower preference was associated with increasing levels of K fertilizer for only 'Beaumont'.
4. Greatest preference was observed in fruits with high measurements of L, W and M, and low measurements of PRES, N, P, K, CA and MG.
5. PRES was the single most highly correlated parameter with TPREF in this experiment, followed by W and K, respectively.

E. RECOMMENDATIONS TO OBTAIN THE HIGHEST DEGREE OF RESISTANCE

1. Determine if increased resistance can be obtained in F_1 generations by evaluating RBT preference of the progeny from a susceptible genotypes (157) and 'Beaumont' (moderately resistant).
2. Establish replicated plantings of 'Allahabad Safeda', Ruby x Supreme and 'Lucknow-49' for advance ratings and greater accuracy on the status of RBT resistance in these genotypes.

3. Cross 'Beaumont' with other clones, such as 180, 'Allahabad Safeda', Ruby x Supreme and 'Lucknow-49', which exhibited moderate resistance among the genotypes studied.
4. Backcross the F_1 progeny obtained in the former crosses with 'Beaumont' to incorporate additional levels of desirable horticultural traits with increased resistance.
5. Broaden the gentic basis of evaluation by including additional *Psidium* genotypes, which had been gathered from other localities.
6. Application of K fertilizer to augment resistant factors already present in the plant. The proper level is dependent upon local biotic and environmental conditions.
7. Periodic monitoring of N and K levels to detect low nutrient levels, which were associated with decreased RBT resistance.

APPENDIX

APPENDIX 1. Percent nutrient content in various guava tissues.

Tissue	Percent nutrient content N	P	K	CA	MG	Reference
Quarters of fruit $(\bar{x})$	0.828	0.185	1.661	0.096	0.105	Table 7
Fruit interior	0.99	0.11	0.55	0.06	0.08	Hiroce *et al.* (1977)
Skin/pulp	0.95	0.10	1.92	0.01	0.13	Brasil Sobr^{o} *et al.* (1961)
Seeds/mucilage coverings	1.16	0.13	1.13	0.01	0.13	"
Third terminal leaf (x)	1.342		1.649			Table 20
Third terminal leaf	3.11		3.67			Rodriquez *et al.* (1968)
Leaf	1.68		1.94			Brasil Sobr^{o} *et al.* (1961)

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